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Seasonal Distribution of Bird Populations at the Patuxent Research Refuge

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U.S.D.I., Fish and Wildlife Service, Patuxent Research Refuge, Laurel, Maryland

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Introduction

Location and Size of Refuge

The Patuxent Research Refuge of the Fish and Wildlife Service, United States Department of the Interior, is an experimental area where research in basic wildlife ecology is being conducted. It occupies 2,656 acres, and is located between Bowie and Laurel, Maryland, on the boundary between Prince Georges and Anne Arundel counties, midway between Baltimore, Maryland, and Washington, D. C. The greater part of the Refuge is bordered by government land; the United States Department of Agriculture's Research Center at Beltsville, Maryland, adjoins the Refuge on the west; Fort George G. Meade adjoins it on the northeast.

History of the Refuge

In May, 1935, the Resettlement Administration turned over to the Biological Survey (now a part of the Fish and Wildlife Service) the tract of land which now comprises the greater part of the Patuxent Research Refuge. This is submarginal land, most of which had been under private

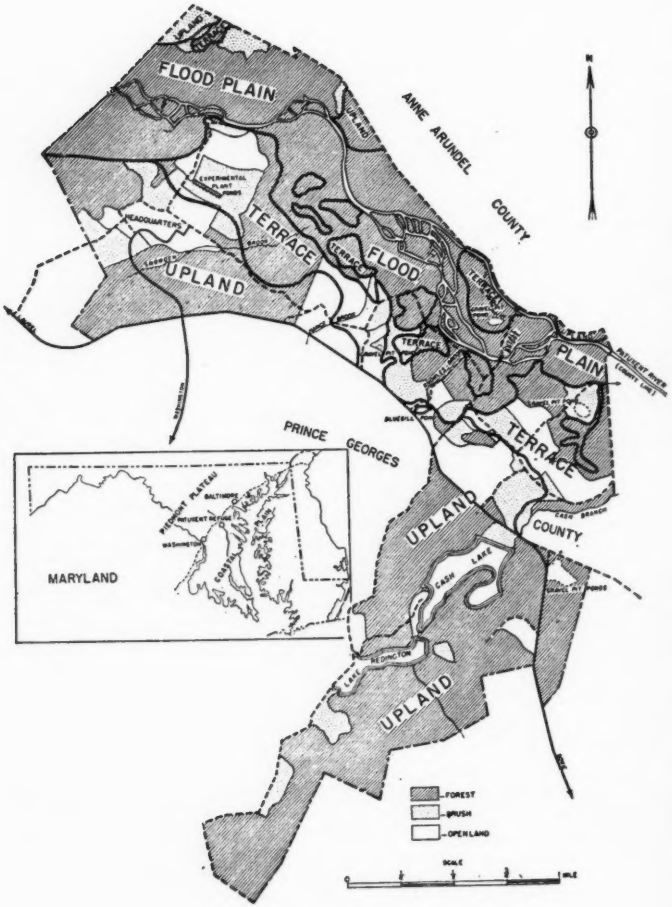

Fig. 1.—Physiography and Plant Cover of the Patuxent Research Refuge. Taken from Hotchkiss and Stewart (1947). (Drawn by Mrs. Katheryne C. Tabb).

ownership up to a year or two before it was acquired by the Federal Government.

After the Refuge was established, gravel roads were constructed, thereby making it possible to reach the various parts of the area by truck or automobile. Some thirteen miles of an eight-foot woven wire boundary fence were put into place, and several more miles of the same have been added as small tracts of land were acquired adjoining the original area. Three laboratory buildings were constructed, and biological collections, chemical laboratories, libraries, and other equipment were installed to enable the wildlife research work to be carried on most efficiently. Several new houses were built and some of the residential buildings already present were renovated so that part of the Refuge personnel could reside on the area. At the same time the residential areas and laboratory grounds were carefully landscaped. During the period 1937-1946 considerable ground was cleared and dams were constructed for four artificial lakes or ponds, which cover about 93 acres.

The Refuge was surveyed and divided into 2½ acre (1 hectare) plots, marked at each corner by a permanent, numbered concrete post. The grid thus created has not only made it possible to record for permanent reference the exact location of bird nests, trapping sites, or various observations of avian activity on the Refuge, but has also been invaluable for census work. After 10 years the parallel trails, 110 yards apart, which run north-south and east-west over the entire Refuge can still be followed, although they are not by any means conspicuous beaten paths.

As a foundation for future research, general surveys of the fauna and flora were started when the Refuge was first established. All of the vertebrates and several groups of invertebrates have been studied fairly intensively, although much more time has been spent on the mammals and birds than on all of the others combined. Studies of the composition and relationships of the various plant communities, and of the occurrence of each species of plant have been completed and the results published (Hotchkiss, 1940, and Hotchkiss and Stewart, 1947).

After the completion of a land use capability plan for the Refuge by the Soil Conservation Service, and a vegetative type map by Refuge personnel, plans were drawn up for the most practical use of the land. In order to keep the area most adaptable for research on animal-environment relationships, it was essential that examples of all existing habitats be preserved and that others be created. Due to the natural progress of succession, this meant that some fields formerly under cultivation would be allowed to lie idle for varying periods of years, and that some wooded areas (those recommended by the Soil Conservation Service as best suited for agriculture) would be cleared.

Since farm areas comprise some of the most important habitats economically, two tracts of the Refuge were set aside permanently for farming. In an experiment now in progress, one of these farms is being operated in a manner similar to the average private farm in surrounding areas, while the

other is being managed according to the recommendations of the Soil Conservation Service. The farming practices on the two areas are being evaluated as to their effects on the production of both crops and wildlife, and on soil fertility.

Part of the forested areas of the Refuge are also being intensively studied. A large tract of the heavily-wooded bottomland forest is being permanently preserved, while other forest areas are open to cooperative projects with the U. S. Forest Service to determine the effects of different kinds of cutting, burning, slash disposal, etc., on the forest and on wildlife. Three forest tracts have been used for the purpose of studying the effects of DDT on wildlife. Other forest areas have been set aside for various types of wildlife population studies.

The initial studies on bird populations, part of which are described in this paper, were completed before most of the management practices on the various habitats had been undertaken. Future work will include the determination of the effects of various types of land use management on bird populations as well as an appraisal of the role that each species plays in this changing environmental complex.

PHYSICAL CHARACTERISTICS OF THE AREA

Climate.—The climate of the region in which the Refuge lies is characterized by hot summers, cool winters and high relative humidity. Temperatures vary considerably, records much above or much below the average occurring at any time during the year. Precipitation is rather evenly distributed throughout the year, being slightly higher in summer and lower in fall and winter, than in spring. However, like temperatures, precipitation is quite variable throughout the year. The total snowfall usually ranges between one and two feet per year, the ground seldom being covered for more than a week at a time. Even in midwinter, rains are more frequent than snow storms.

At the Bell Weather Station, near Glenn Dale, Maryland, three miles south of the Refuge, records have been kept for 27 years. According to the 1947 summary of these records (Climatological Data, 1947) the average annual temperature was 54°, and monthly averages varied from 34° in January to 76° in July. Extreme temperatures during the period 1943 to 1947 inclusive, were −4° and 99°. The interval between the last killing frost in the spring and the first in the fall was usually about 175 days. The extreme dates of killing frost varied as much as a month from year to year. The average dates of the last killing frost in spring and first killing frost in fall were April 27 and October 16, respectively. The average annual precipitation was 42½ inches, and monthly averages varied from 2½ inches in December to 4½ inches in August. The prevailing winds were moderate and from the northwest.

Physiography.—The Refuge is situated on the Atlantic Coastal Plain within the Fall-line Clay Hills District (Harper, 1918), four miles east of

the boundary of the Piedmont Plateau, and 20 miles west of Chesapeake Bay. Most of it lies within the Patuxent River valley, which at this point is about three miles wide and 150 feet deep.

Altitudes vary from 80 feet above sea level along the river at the east end of the Refuge to 240 feet at the highest point on the upland. The river falls about 20 feet in its crooked, 3½-mile, southeasterly course across the Refuge, traversing for the entire distance a flood plain that varies from one-quarter to one-half mile in width. Irregular areas of broad, nearly level terrace adjoin the flood plain in many places, or occur as "islands" within it, the relief between the two being less than 15 feet. The upland slopes gently but irregularly from the terrace to broad hilltops. In a few places where the upland adjoins the flood plain, steep bluffs up to 50 feet in height are present.

Four lakes or ponds were constructed by the damming of small streams in the upland. The lower course of Cash Branch was dammed in two places to form lakes; Cash Lake, with an area of 53 acres, was completed in 1939, and Lake Redington, with an area of 31 acres, in 1944. Snowden Pond and Bluegill Pond cover 7½ acres and 2 acres respectively, and were formed by the damming of Snowden Brook in 1947 and Knowles Brook in 1945. Open, shallow water also occurs in four gravel pits on the Refuge as well as in a series of twenty-four 20 x 50-foot experimental ponds for plant studies.

Soils.—The soils are extremely variable over different parts of the Refuge. Those on the upland have been formed by the weathering of the underlying Coastal Plain sediments, while much of the soil on the flood plain and terrace is composed of alluvial material derived from the nearby Piedmont Plateau. In fertility, the soils vary from the rich Congaree Silt Loam on many of the terrace areas, to the infertile, highly erodible Tuxedo soil which occurs extensively over much of the upland. In texture, they vary from silt loams to gravelly sands; in water-holding capacity, from those that are water-logged to those that are excessively drained; and in pH, from those that are neutral to others that are strongly acid. The content of organic matter is low in most of the soils. On the upland much of the topsoil has been worn out by intensive tobacco farming in the past or has been lost completely by gully and sheet erosion.

BIOLOGICAL CHARACTERISTICS OF THE AREA*

Plant Communities.—Most of the Refuge is now covered with forests of various types. On the flood plain, these forests are composed entirely of hardwoods, while on the terrace and upland the forests may be pure pine, pure hardwood, or mixed stands of pine and hardwood. Practically all of the forests on terrace and upland represent secondary stages of succession on land that had been cultivated within the last 100 years. The flood plain

* Scientific names of plants used in this discussion are taken from "Vegetation of the Patuxent Research Refuge, Maryland" (Hotchkiss and Stewart, 1947).

forest has been logged over from time to time, except on some of the islands between the river channels.

Whenever agricultural fields are abandoned on the terrace or upland, numerous annual weed species invade the areas and soon become dominant. After two or three years these are almost entirely replaced by perennial species, of which Broomsedge (*Andropogon virginicus*) is generally the most abundant. Woody plants appear for the first time soon after this. The well-drained areas are regularly invaded by pines, mostly Virginia Pine (*Pinus virginiana*) and Pitch Pine (*Pinus rigida*), while the poorly-drained sites generally become dominated by Sweetgum (*Liquidambar styraciflua*). Within a few years, these develop into dense even-aged stands. Finally, the characteristic species of the more mature forests make their appearance, both pine stands and sweetgum stands being invaded by a variety of deciduous trees. Beech (*Fagus grandifolia*) and White Oak (*Quercus alba*) predominate in the climax terrace forests, while White Oak, Scarlet Oak (*Quercus coccinea*) and Black Oak (*Q. velutina*) are the most characteristic species of mature forests on well-drained upland, although certain other oaks and hickories are quite common locally. The assortment of trees found on poorly-drained upland and terrace often includes species characteristic of the better-drained areas associated with typical swamp species such as Red Maple (*Acer rubrum*), Blackgum (*Nyssa sylvatica*), Holly (*Ilex opaca*), and Willow Oak (*Quercus phellos*).

The more important plant communities on the flood plain are represented by several types of shrub swamps and flood plain forests. The relationships of these communities are complicated by differences in water supply, drainage, deposition of alluvium, and by different stages of recovery from logging or clearing. The shrub swamps are composed largely of Alder (*Alnus serrulata*), Swamp Rose (*Rosa palustris*), Poison Sumac (*Toxicodendron vernix*), and several other associating species. The composition of the flood plain forests is extremely varied, slight differences in elevation accounting for striking changes in the vegetation of localities only a few feet apart. The more common tree species include: Sweetgum, Hornbeam (*Carpinus caroliniana*), River Birch (*Betula nigra*), Tulip-tree (*Liriodendron tulipifera*), Red Maple, Pin Oak (*Quercus palustris*), and Beech.

Many of the fields on the Refuge are bordered or dissected by hedgerows and wood margins, which are dominated by a variety of trees having a dense understory of shrubs and woody vines. The composition of the vegetation in these habitats varies considerably from place to place, depending on their relative age or development, and on the amount of moisture in the ground. Some of the more characteristic woody plants are: Sassafras (*Sassafras albidum*), Sweetgum, Black Cherry (*Prunus serotina*), Persimmon (*Diospyros virginiana*), Greenbrier (*Smilax* spp.), Highbush Blackberry (*Rubus* spp.), and Wild Grape (*Vitis* spp.).

The approximate acreages of the major habitat types on the Refuge are indicated as follows: 1816 acres of forest land (1102 acres of terrace and

upland forest and 714 acres of flood plain forest); 399 acres of brushland (brushy upland, shrub swamps, hedgerows and wood margins); 282 acres of cleared land (including 209 acres of cultivated fields and pastures and 73 acres of abandoned fields and meadows); 93 acres of lakes and ponds; and 66 acres of residential areas, orchards, gravel pits, and other miscellaneous habitats.

Characteristic Animals (other than birds).—Thirty-one species of wild mammals have been recorded on the Refuge. Of these, the most common (considering their habits) were the Raccoon (*Procyon lotor*), Gray Fox (*Urocyon cinereoargenteus*), Gray Squirrel (*Sciurus carolinensis*), Short-tailed Shrew (*Blarina brevicauda*), Deer Mouse (*Peromyscus leucopus*), and Pine Mouse (*Pitymys pinetorum*). Other species which occurred fairly commonly include the Opossum (*Didelphis virginiana*), Skunk (*Mephitis mephitis*), Red Fox (*Vulpes fulva*), Woodchuck (*Marmota monax*), Cottontail Rabbit (*Sylvilagus floridanus*), Big Brown Bat (*Eptesicus fuscus*), Red Bat (*Lasiurus borealis*), Flying Squirrel (*Glaucomys volans*), Meadow Mouse (*Microtus pennsylvanicus*), and House Mouse (*Mus musculus*). Stray dogs and cats were also frequently seen.

The cold-blooded vertebrates that have been recorded on the Refuge include 3 species of lizards, 16 species of snakes, 7 species of turtles, 12 species of frogs and toads, 10 species of salamanders, and 37 species of fish. Among the more common terrestrial species should be listed the Pilot Black Snake (*Elaphe obsoleta*), Black Racer (*Coluber constrictor*), Box Turtle (*Terrapene carolina*), Fowler's Toad (*Bufo fowleri*), and Red-backed Salamander (*Plethodon cinereus*). Many of the aquatic and amphibious species were equally as common, although much more restricted in habitat.

The surveys of the invertebrate fauna have not been completed and therefore it is not possible at this time to give a satisfactory sketch of its character or abundance.

The Avifauna.—The number of native species of birds recorded for the Refuge is 227, based on the species accepted by the 4th Edition of the A. O. U. Check-List, 1931, and the 6 subsequent supplements. To this may be added two introduced species, the Starling and the English or House Sparrow, which have been thoroughly established in this area for many years. The total Refuge list of 229 species contains 74 percent of the 309 species on the Maryland list (Hampe and Kolb, 1947; Stewart, 1947a and 1947b). Two hybrids, the Brewster's Warbler (*Vermivora leucobronchialis*) and Lawrence's Warbler (*Vermivora lawrencei*), have also been recorded as have numerous subspecies which will be discussed in another paper.

The land birds of the Patuxent Refuge may be considered fairly typical of those found in the Fall-line Clay Hills District of the Atlantic Coastal Plain in Maryland. Three species, Purple Martin, Yellow Warbler, and Grackle were found to nest commonly in the nearby towns of Laurel and Bowie, but have not been found breeding on the Refuge. Martin houses

have been erected but were promptly taken over by Starlings in spite of annual control practices during the early nesting season. The Yellow Warbler and Grackle did not find the right habitats on the Refuge and were seldom seen here during the breeding season. The Loggerhead Shrike has nested on the Beltsville Research Center grounds, one mile away, but has not been recorded as a breeding bird on the Refuge.

The predominant species in the avifauna are those characteristic of the Oak-pine region of the Deciduous Forest Biome (Braun, 1947). The Refuge is well situated as far as the migration of land birds is concerned. The variety of birds and the number of individuals seen on the Coastal Plain (and particularly along the flood plain of the Patuxent and other rivers) is greater than in other parts of the state at all seasons of the year.

Water birds, marsh birds, and shorebirds were, in general, comparatively scarce on the area. This is due in part to the fact that the Refuge is located outside of the major flight lines, the nearest of which follows the Chesapeake Bay. Ducks were seldom seen in flight over the Refuge, although during migration periods occasional small flocks were seen on the lakes or ponds. They rarely remained for more than a few hours, however, since the water was so badly silted or stained that aquatic plant growth was greatly inhibited, resulting in a sparse food supply. The general scarcity of suitable habitats was also undoubtedly partially responsible for the low number of marsh birds and shorebirds that were recorded. As marshes develop and more duck food becomes available in the lakes and ponds, several new species will probably be added to the Refuge list, and populations of many species may be expected to increase.

Certain extinct or extirpated species as well as others which have been introduced but have not successfully established themselves, are described as follows:

Ruffed Grouse (*Bonasa umbellus*): This species formerly occurred throughout the region, but no native individuals have been seen since about 1920 when R. Bruce Overington, of Laurel, Maryland, saw one two miles west of the Refuge and another about three miles to the north. During the fall of 1946 five birds, which had been trapped near Blacksburg, Virginia, were released on the Refuge in an attempt to re-establish the species. Single individuals were seen on or near the Refuge through the following spring, but it is doubtful whether any now remain.

Ring-necked Pheasant (*Phasianus colchicus*): Although this species has been introduced in several counties of Maryland it has not become established in this part of the state. From one to five birds have been seen on the Refuge on three occasions, but it is possible that these had recently escaped from captivity or had been liberated on lands adjoining the Refuge.

Wild Turkey (*Meleagris gallopavo*): Wild turkeys were occasionally noted between 15 and 20 miles to the southwest and west of the Refuge until the end of the last century (Kirkwood, 1895), but no records of native birds from the immediate vicinity have been found. In 1937 and

1938 two dozen game farm birds were released on the Refuge in the hope that they would establish themselves. However, these birds all disappeared within a few months.

Rock Dove (*Columba livia*): The domestic pigeon, or Rock Dove, can scarcely rate as part of the natural avifauna. That the vast majority of pigeons which pass over here are captive birds is obvious from the fact that the species was seldom recorded except on weekends and holidays when local pigeon fanciers were out exercising their pets. Most of the stray birds which were occasionally noted during the week wore bands, showing that they had been in captivity at one time.

Passenger Pigeon (*Ectopistes migratorius*): Although no actual records of this species were found for the Refuge area, one of the last Maryland records was of two or three birds taken from a small flock about one mile northwest of here in the fall of 1889 by George Marshall of Laurel (Cooke, 1929).

Some mention should be made of those species not yet recorded which have been seen several times in surrounding areas and may be expected to occur on the Refuge. These are the following:

Red-throated Loon (*Gavia stellata*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Louisiana Heron (*Hydranassa tricolor*)
European Widgeon (*Mareca penelope*)
White-winged Scoter (*Melanitta deglandi*)
King Rail (*Rallus elegans*)
Yellow Rail (*Coturnicops noveboracensis*)
Black Rail (*Laterallus jamaicensis*)
Black-bellied Plover (*Squatarola squatarola*)
Willet *Catoptrophorus semipalmatus*)
Knot (*Calidris canutus*)
Stilt Sandpiper (*Micropalama himantopus*)
Laughing Gull (*Larus atricilla*)
Forster's Tern (*Sterna forsteri*)
Caspian Tern (*Hydroprogne caspia*)
Snowy Owl (*Nyctea scandiaca*)
Short-eared Owl (*Asio flammeus*)
Chuck-will's-widow (*Caprimulgus carolinensis*)
Arkansas Kingbird (*Tyrannus verticalis*)
Northern Shrike (*Lanius excubitor*)
Pine Grosbeak *Pinicola enucleator*)
Red Crossbill (*Loxia curvirostra*)
White-winged Crossbill (*Loxia leucoptera*)
Sharp-tailed Sparrow (*Ammospiza caudacuta*)
Snow Bunting (*Plectrophenax nivalis*)

METHODS OF STUDY

Seasonal Population Fluctuation Study.—Seasonal changes in bird populations were intensively studied for two years on one study area which was 2.6 miles long, 990 feet wide and covered approximately 304 acres. This area included representative examples of most of the more important terrestrial habitats on the Refuge. It did not contain adequate samples of Shrub Swamps, Transition Swamps, Sweetgum Fields, Pine Stands and Pine-Oak Forests. The approximate acreage of the habitats that it did include are listed as follows: Upland Oak Forest—42 acres; Bluff Forest—14 acres; Terrace Forest—31 acres; Seepage Swamp Forest—35 acres; River Swamp Forest—20 acres; Bottomland Forest—29 acres; Pine Fields—21 acres; Abandoned Fields—22 acres; Agricultural Fields—18 acres; Residential Areas—20 acres; and Miscellaneous Habitats (hedgerows, wood mar-

gins, gravel pits, and other habitats represented by small areas)—52 acres. The plant composition and successional relationships of all of these habitats are described in detail by Hotchkiss and Stewart (1947).

This study was started on July 27, 1943, and ended on July 26, 1945. Census trips over the area were conducted twice a week from July 27 through November 17, and from March 1 through June 1, but during the intervening periods, when weekly changes in population were comparatively slight, only one trip was made each week. A special effort was made to take trips only during favorable weather conditions; rains and high winds particularly were avoided. The trips were started about one hour after sunrise and lasted about three hours each.

Every census trip was made by three observers walking along parallel plot lines 330 feet apart over the 2.6-mile course. Each observer recorded all birds seen or heard that were located within 165 feet of the line that he was following (the three observers together thus recording all birds seen or heard in the strip 990 feet wide). Although the observers frequently could not see each other, they kept abreast by calling to each other at stated locations. Separate lists of birds recorded were kept for each habitat area covered. At the end of the trip the individual lists were checked to avoid possible duplication of birds flying from one line to another.

Extensive Breeding Bird Census.*—The extensive counts of breeding birds involved single, systematic coverages of the entire Refuge, wherein every pair of birds observed (or singing males, which may be assumed to represent pairs in a high percentage of cases for most species that nest on the Refuge) was recorded on a field map and later plotted on large species maps. The population figures derived from records of this type are far below the actual populations of most species, since on the average only about half of the pairs present were recorded on a single trip through an area. The number of pairs observed on a single census trip compared to the total number of pairs known to be present varied greatly with the species concerned. The percentages of pairs observed as determined from more intensive studies amounted to about 80 percent for the Hooded Warbler and Pine Warbler, but only 36 to 39 percent for the Ruby-throated Hummingbird and Worm-eating Warbler.

The extensive breeding-bird census was conducted from April to July (inclusive), 1943, by three observers walking along parallel plot lines 330 feet apart in the early morning, on days with favorable weather conditions. Census trips were promptly terminated as soon as the wind became strong

* The terms extensive and intensive as applied to censuses in this paper indicate whether the bird counts were obtained in a single coverage of a large area or whether a figure approaching the actual population was obtained from a series of trips over a small area.

enough to interfere with observations, or whenever a noticeable reduction in singing occurred. The entire Refuge was covered three times: in April for hawk, owl, and crow nests; in May for woodpeckers and early-nesting passerine species; and in June for most other nesting species. Special trips were made at various times during July to areas where the late-nesting Goldfinch and Cedar Waxwing were found. In addition to the regular census trips, the Refuge was systematically covered in the evening or at night for owls, Whip-poor-wills and Woodcock. The hawk count was determined almost entirely by the location of nests, although enough observations were made in all parts of the Refuge to determine the approximate territories of Raptores whose nests were not found.

Intensive Breeding Bird Census.—An approximation of the actual breeding bird populations in each of the major habitats on the Refuge was arrived at by intensive breeding bird censuses. Starting in the spring of 1944, uniform study areas, generally of 25 acres or more, were censused in each habitat. These censuses were particularly useful in the present study for obtaining a correction factor for the extensive censuses.

The census technique used was similar to that of Williams (1936) except that much more emphasis was given to the recording of individuals of the same species that were noted singing simultaneously or that had songs so distinct that they could be recognized from one trip to another. From 8 to 40 or more censuses were made on each study area, mostly during the early morning. All birds observed were recorded with appropriate symbols to designate sex, age, whether singing, carrying nesting material, etc. A separate map was used for each census trip, and later all records were transferred to species maps. From the resulting clusters of records, and particularly from records of males singing simultaneously, it was possible to outline the approximate territory of each pair. The number of territories on each area indicated the number of pairs of the species in question. Where a territory overlapped the boundary of an area, only the fractional part of the territory falling within the study area was counted. Since the population densities were expressed in terms of pairs per 100 acres, and all study areas were of 40 acres or less, considerable error would have been introduced if the densities had been computed from whole numbers only.

Extensive Winter Bird Census.—The approximate wintering bird populations during the winters of 1943-1944 and 1944-1945 were determined by extensive winter bird censuses. These were taken during the periods January 13 to February 16, 1944, and January 17 to February 23, 1945.

The census techniques that were used on the wooded areas were entirely different from those used on the open areas. All of the forest stands were systematically covered by three observers who walked along parallel plot lines 330 feet apart. Whenever a flock of birds was found midway between two census lines, two observers converged upon the birds in order to insure an accurate count. The positions of all birds observed were recorded on field maps. In covering large areas of forest the three observers, after traversing

one 990-foot strip would return along an adjacent strip of the same width. Birds which had been counted on one strip and were believed to have moved to the adjoining one by the time the observers had returned, were deliberately counted a second time on the assumption that on the average an equal number had moved back on strips already covered, without being observed.

The open areas were censused by using a crew of men to drive the birds slowly ahead past certain points where observers were so stationed that they could count and identify the individuals as they passed by. The members of the driving crew walked parallel to each other and systematically covered each field. Many of the smaller fields were covered in single sweeps, but in the case of the larger areas it was usually necessary to use several different approaches in such a way that birds which were flushed from one part of the area were not chased over to other parts that had not been covered. Occasional birds which were by-passed or which flew in the wrong direction were accounted for.

Special methods were used to check species which could not be accurately counted by the more general census methods. The coveys of Bob-white were located principally from numerous observations over the Refuge, which were made incidental to censuses of other species or to other types of field work. The number of individuals in many of the coveys was determined by counting the number of individual trails in the snow. The owls were counted by supplementing the census information from night trips, with data accumulated during an intensive banding program. Hawks, vultures, and crows were counted on special, one-day censuses in which seven or eight people participated. Observers, stationed at prominent locations from which nearly the entire Refuge could be seen, made simultaneous counts of crows and vultures each half hour and kept continuous records of all hawks observed. At the same time another observer traveled from one area to another flushing as many hawks, vultures, and crows as could be found. In determining crow and vulture populations, the average number on the Refuge at any one time was used.

Winter Surveys.—Starting in December, 1941, a one-day survey of the entire Refuge was made each winter (except 1942) in late December or early January. These surveys were conducted as uniformly as possible each year so that they would furnish reliable comparative data on the wintering populations. Some of these counts were submitted as "Christmas Censuses" to *Audubon Magazine*, and later to *Audubon Field Notes*, but they differed from the ordinary Christmas count in that they represented uniform, intensive coverage of a relatively small area, instead of a superficial coverage of the most productive spots within a larger area. In conducting the winter surveys, the Refuge was divided into seven sections, each of which was covered by one man or a party of two. The time spent in each habitat was roughly proportional to its extent within the area, but the early morning hours were often spent in the most productive habitats.

The seven winter surveys were taken on the following dates: December 23, 1941; December 23, 1943; December 29, 1944; December 28, 1945; December 26, 1946; January 16, 1948; and January 14, 1949. The weather during the seven counts was somewhat variable. A slight amount of rain occurred in 1941 and 1945, but not enough to interfere seriously. Winds were light every year, and in no case was there more than one inch of snow on the ground.

Accuracy of Census Methods.—The accuracy of the census methods employed in these studies varied according to the type of census and the species involved. The most accurate censuses were those which were based entirely upon the location of nests during the breeding season. This method was used for Barn Swallows, Phoebes, and others whose nests were comparatively easy to find. For these species, the census totals are believed to be 100 percent accurate. Unfortunately, most birds nest in habitats where it is impractical to attempt to locate all nests.

The breeding populations in most of the study areas were largely determined by counting the number of occupied territories. For certain birds, the determination of nesting territories is very difficult unless the method of plotting singing males is used. This is especially true for abundant species such as the Red-eyed Vireo, in which the sexes are similar or identical in external appearance. Since in most species only the male sings, and since the plotting of singing males is by far the least time-consuming of the various ways of measuring breeding bird populations, this method was used in most cases. This method of censusing has been criticized with some justification on the basis that all singing males may not be mated, that mated males of some species may sing very little, or that a single male may have more than one mate at the same time. Whenever these conditions were suspected to apply to any great extent, special checks such as the location of nests, were resorted to.

The accuracy of the intensive breeding bird censuses is estimated to be above 90 percent for nearly every species, and to average over 95 percent. These estimates are based on experience in censusing numerous study areas which cover all of the important habitats of the Refuge. In certain cases as many as 40 census trips were taken on a study area during a single season.

The accuracy of the extensive breeding-bird censuses was checked against similar single trips through study areas where the approximate breeding-bird population had been determined. It was found that the number of pairs (or singing males) recorded on average trips varied from 36 percent (Worm-eating Warbler) to 81 percent (Hooded Warbler) of the total population. The average percentages of the total breeding populations that were recorded on a single trip for various species were computed from a series of 30 to 75 early morning trips through areas where a close approximation of the nesting populations had been determined. These percentages are listed for ten common species in the following table:

TABLE 1.—Accuracy of a single census trip during breeding season

Species	Percent of Population Recorded
Ruby-throated Hummingbird	39
Downy Woodpecker	47
Acadian Flycatcher	63
Tufted Titmouse	68
Carolina Wren	49
Wood Thrush	47
Red-eyed Vireo	50
Kentucky Warbler	61
Redstart	39
Scarlet Tanager	65

The population figures from the extensive breeding-bird censuses were revised according to the correction factor for a single census trip as determined from the intensive breeding population studies. The resulting figures represent our closest approximation of the actual breeding population for the entire Refuge.

The accuracy of the extensive winter bird censuses can only be roughly estimated, since not enough similar trips have been taken at this season through areas where the actual population was known. In the case of birds of the open fields it is certain that over 90 percent of the population was recorded. In wooded regions, and particularly in areas of shrub swamp and thick tangle, the percentage of error was undoubtedly much greater. Certain species characteristic of these habitats such as the Yellow-bellied Sapsucker, Brown Creeper, Winter Wren, and Hermit Thrush are quite secretive and are sometimes difficult to observe. However, the more conspicuous woodland species, such as woodpeckers, chickadees, titmice, and kinglets were recorded with much greater accuracy.

The chief value of the winter survey figures lies in their year to year comparisons, as they are not intended to represent the actual number of birds present. Between 50 and 70 percent of the wintering populations (as computed from extensive winter censuses) was recorded during these winter surveys each year. The percentages for different species varied greatly but were probably fairly constant from one year to another.

Likewise figures from the seasonal population study are intended only as relative numbers and are used to compare populations in the same habitats from one season to another. The accuracy of these counts probably varied considerably during the year since many of the censuses involved were taken during seasons when the bird populations were continuously changing.

General Observations.—In addition to the regular censuses which have been described, many special counts and observations were recorded for all

seasons. All major habitats were visited at frequent intervals throughout the year in order to be sure that important population changes of characteristic species would not be missed. During periods of migration, daily records were kept of transients observed, and periodic checks were made of bird populations in special study areas. Frequently when large migratory flights were expected because of optimum weather conditions, one or two observers would spend the entire day making a general coverage of the Refuge, visiting all habitats and recording the numbers of birds observed. Information of this kind was recorded on 3½ x 5½-inch cards, filed according to species and used to supplement the data obtained from the regular censuses.

Various types of detailed field studies on specific problems were conducted during the breeding season and winter. The breeding populations of several local or conspicuous species were censused year after year in order to obtain information on yearly variation. Considerable time was spent on analyzing environmental factors concerned with the ecological requirements of birds during the nesting season. The significance of food habits as correlated with seasonal and habitat distribution of birds was evaluated, particularly for the winter months. Intensive winter censuses of the major habitats on the Refuge were taken during the winter of 1942-43. Field work on problems such as these contributed much information on the seasonal distribution of birds.

Many of the occurrence records cited in the paper are of birds taken in banding traps. These traps proved invaluable in supplying quantitative data on migration peaks, duration of migration, and extreme arrival and departure dates, in addition to data on local movements, migration routes, population turnover, etc. Altogether approximately 15,000 individuals of 129 species were banded on the Refuge during the period 1943 through the early part of 1948. To this number may be added nearly 16,000 "repeat" records and about 850 "returns."

ACKNOWLEDGMENTS

The constant encouragement and moral support of Arnold L. Nelson and Ira N. Gabrielson have been most stimulating and have helped immeasurably in facilitating the completion of these investigations. Dr. Gabrielson also contributed many notes on birds that he has observed or collected on the Refuge since 1936.

Other people have helped in numerous ways. Leonard M. Llewellyn, in particular, has spent considerable time and energy on the Refuge bird-banding program which has helped to clarify the status of many species. M. Brooke Meanley has contributed very useful field notes on migrating birds and has collected several valuable specimens. These, and other phases of the study, have also been materially helped through the generosity of the following: John W. Aldrich, Barbara Brainerd, Don R. Coburn, Clarence Cottam, Lucas M. Dargan, Allan J. Duvall, John N. Hamlet, Neil Hotchkiss, Father Fabian Kekich, A. C. Martin, Frank May, Robert T. Mitchell, R. Bruce Overington, Lloyd Poland, Paul F. Springer, Irene S. Stewart, Marjorie J. Stewart, Katheryne C. Tabb, and Francis M. Uhler.

Seasonal Changes in Bird Populations

MAJOR SEASONAL TRENDS IN POPULATIONS OF LAND BIRDS

The species composition of the Refuge bird populations, as well as the number of individuals, was found to undergo almost continuous change throughout the year except for brief periods during mid-winter and early summer. During these periods both the numbers of species and individuals were comparatively low but remained fairly stable. The number of species present during the winter was about two-thirds of the number occurring in early summer. The actual populations were also somewhat lower in winter, although the exact extent was difficult to determine since the census methods used during the two periods were not comparable in accuracy.

As would be expected, the greatest numbers of species and individuals occurred during periods of migration. The number of species occurring on the Refuge at one time was highest in the spring, while the number of individuals was highest in the fall. The high number of species in spring was due primarily to a greater overlap in the migration periods of the various species, while the higher number of individuals in fall was undoubtedly due to the production of young birds during the intervening breeding season. The total population during the fall migration peak was more than four times as great as the population during winter or summer, and about twice as great as the numbers present during the peak migration in spring.

A few species were much more numerous in spring than in fall. For transient species this difference, when it existed, was believed to be due largely to changes in migration routes between spring and fall, although the greater conspicuousness of most species in spring was undoubtedly a contributing factor in some cases. Summer resident species which showed this tendency were usually those near the northern limit of their breeding range. Individuals of these species quietly slipped away during the fall migration and since their numbers were not appreciably augmented by transients from the north, they appeared to be much less common in fall.

The highest number of species on the Refuge during the migration period occurred within the population peaks of the insectivorous species, while the highest number of individuals were present during the population peaks of omnivorous or herbivorous species. The population peaks of insectivorous birds occurred later in spring and earlier in fall than the corresponding peaks of omnivorous and herbivorous species, the interval between the two being about 40 days in the fall and 60 days in the spring. In spring there was a pronounced slump in the total population during the intervening period between the two major migration peaks.

The ecological affinities of the bird populations differed greatly from one season to another. Species characteristic of edge habitats were proportionately much more prevalent in winter, while forest species were predominant in summer. Birds that are chiefly insectivorous comprised from 40 to 60 percent of the total population during late spring, summer and early fall, but only 5 to 10 percent during late fall, winter, and early spring. Two

of the most characteristic families of birds on the Refuge were the *Fringillidae*, which is primarily herbivorous or omnivorous, and the *Parulidae*, which is mainly insectivorous. The *Fringillidae* made up roughly one-half or more of the total population during the late fall, winter, and early spring, but accounted for less than one-fourth of the population during late spring, summer, and early fall. The *Parulidae*, on the other hand, comprised about one-fourth of the late spring and early summer and one-fifth of the late

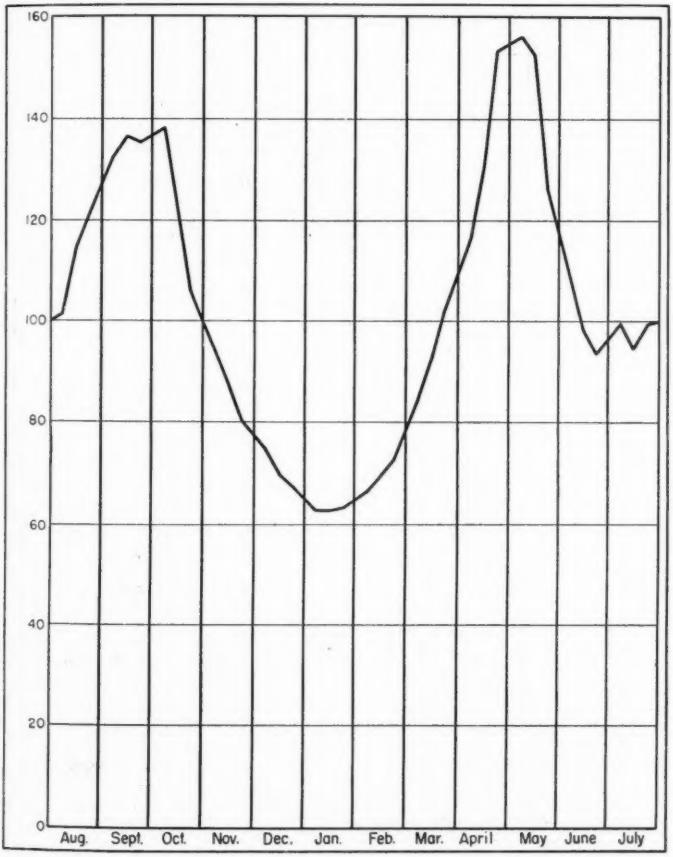

Fig. 2.—Total number of species of birds that have been recorded on the Patuxent Research Refuge for each ten-day period throughout the year

summer and fall population, but was of minor importance during winter.

The data from the two-year seasonal population study indicated that species which occurred as permanent residents accounted for 35 to 45 percent of the total population throughout the year. Those that were present

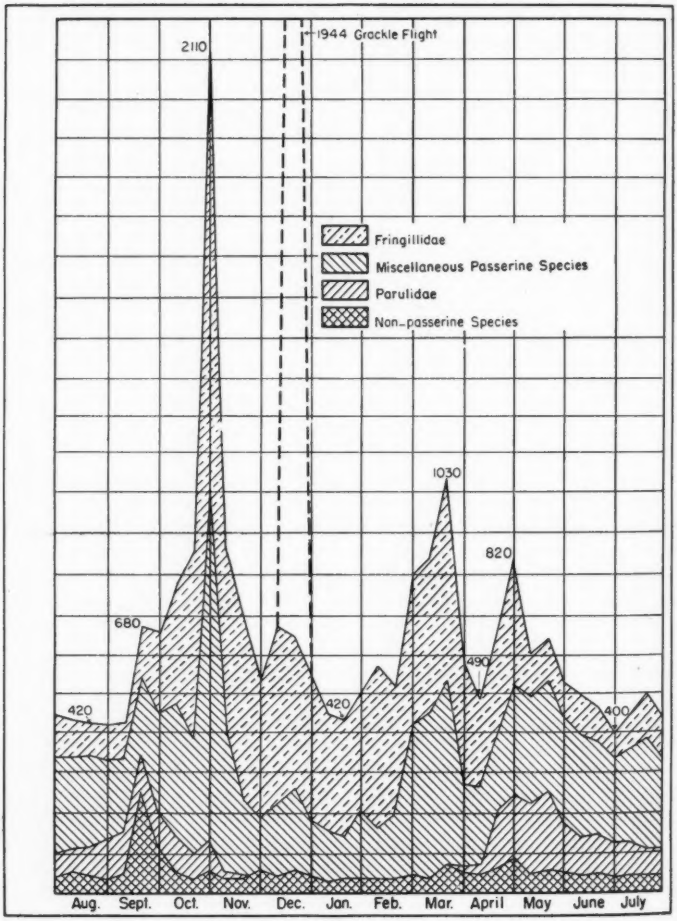

Fig. 3.—Seasonal changes in the total population of individuals of the more important (numerically) taxonomic groups of birds. (Data are taken from two-year seasonal population study.)

on the Refuge during the winter but not in summer comprised about 60 percent of the wintering bird population, 50 percent of the numbers during the fall migration peak, and 25 percent of the peak population in spring. Other species which occurred regularly during the summer but not in winter

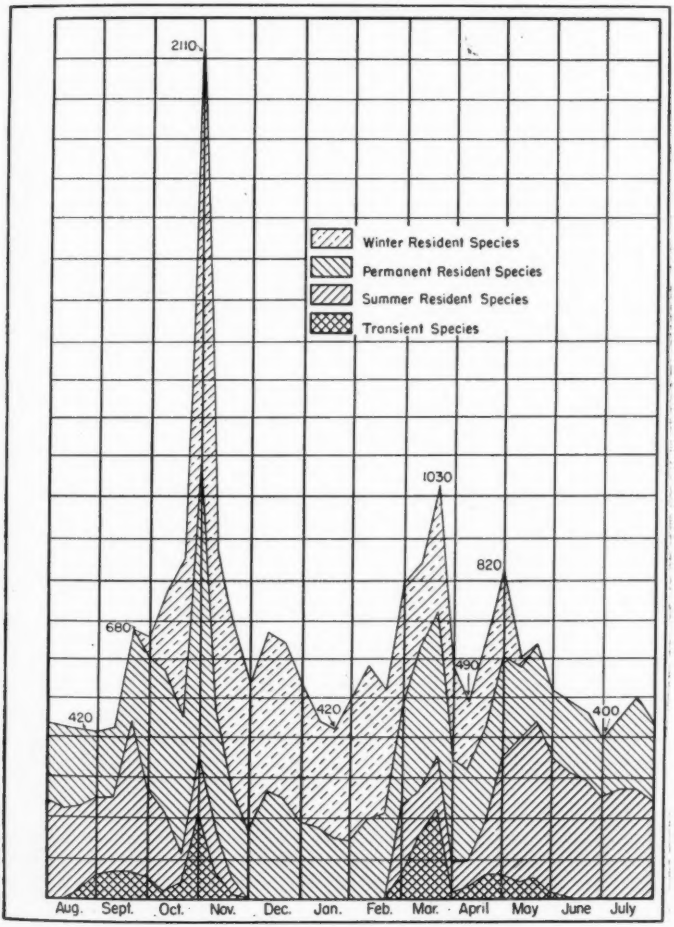

Fig. 4.—Seasonal changes in the total population of individuals of the four major seasonal groupings of species

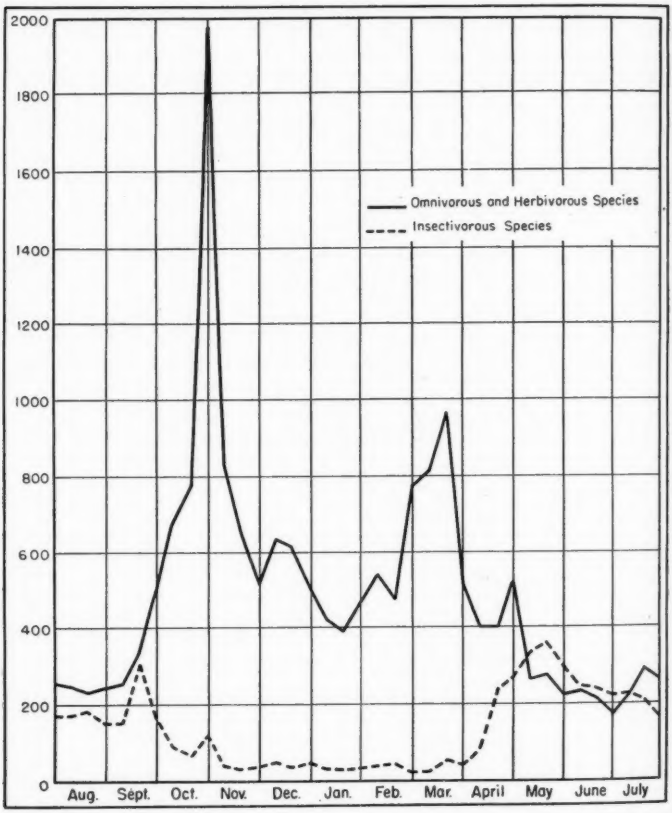

Fig. 5.—Seasonal distribution of populations of omnivorous and herbivorous birds as compared with populations of insectivorous birds*

* Omnivorous and herbivorous birds (with food habits averaging more than 25% plant food) include the following families or groups: *Perdicidae, Columbidae, Picidae, Alaudidae, Corvidae, Paridae, Sittidae, Mimidae, Turdidae, Bombycillidae, Sturnidae, Dendroica coronata* (Myrtle Warbler), *Ploceidae, Icteridae* (except genus *Icterus*), and *Fringillidae.* Insectivorous birds include the following families or groups: *Cuculidae, Caprimulgidae, Apodidae, Trochilidae, Tyrannidae, Hirundinidae, Certhiidae, Troglodytidae, Sylviidae, Motacillidae, Vireonidae, Parulidae* (except Myrtle Warbler), genus *Icterus,* and *Thraupidae.* Data are taken from two-year seasonal population study.

comprised from 55 to 65 percent of the summer and early fall populations, and about 40 percent of the late spring population. The transient species generally accounted for 10 to 15 percent of the population in fall and from 10 to 20 percent during the spring. The exact proportions of these various groups during the different seasons varied considerably from year to year. In 1943 for example, the Refuge breeding census figures showed that the summer resident species comprised 82 percent of the breeding population, with the remainder being permanent resident species. These figures are quite different from those derived from the seasonal population study.

TABLE 2.—Seasonal distribution of major families of small land birds. (Data from two-year seasonal population study, showing average number of individuals seen per census trip for each ten-day period throughout the year. A plus sign (+) indicates that the average number recorded was less than one-half).

	January			February			March			April		
	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4
Cuculidae												1
Apodidae										1	5	27
Trochilidae												1
Picidae	22	29	27	30	23	21	20	30	21	21	14	14
Tyrannidae							1	7	7	5	3	11
Alaudidae			8	4		2	1	1	1	1	2	1
Hirundinidae									1	1	12	40
Corvidae	22	13	19	27	90	40	31	21	33	21	25	41
Paridae	43	20	31	34	29	33	37	32	31	29	26	20
Sittidae	7	4	7	6	9	7	6	6	5	2	1	2
Certhiidae	4	5	2	5	4	1	2	3	4	4	2	2
Troglodytidae	4	3	1	3	4	1	3	2	2	3	9	10
Mimidae	2	2	3	1	2	3	4	5	4	5	6	12
Turdidae	10	9	17	18	11	39	66	88	47	29	32	39
Sylviidae	22	20	12	9	12	8	5	4	7	13	24	13
Motacillidae								9				
Bombycillidae	21	16	1			13	4	+	1	6	5	4
Sturnidae	2	15	7	16	25	28	15	14	13	12	15	18
Vireonidae										+	2	31
Parulidae	3	6	4	9	4	5	6	7	11	28	135	151
Ploceidae			1		1	1	1	1	2	1	1	2
Icteridae			60	2	2	198	207	252	63	21	19	19
Thraupidae												7
Fringillidae	281	278	289	413	318	379	399	503	307	231	278	307
Total	443	420	489	577	534	779	808	985	560	434	797	773

TABLE 2.—(*continued*)

	May			June			July			August		
	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4
Cuculidae	4	4	3	2	2	3	4	3	3	4	4	1
Apodidae	21	17	23	8	16	4	7	13	17	18	14	11
Trochilidae	3	5	6	3	6	6	4	5	4	4	3	6
Picidae	8	14	11	14	11	10	17	9	10	13	11	9
Tyrannidae	17	29	40	35	30	25	30	28	21	19	15	11
Alaudidae	+	+		1		1						
Hirundinidae	22	8	6	4	5	8	8	18	10	12	7	5
Corvidae	20	10	9	7	11	6	4	3	8	11	6	4
Paridae	17	25	27	38	32	38	29	37	25	29	39	36
Sittidae						+			+			
Certhiidae												
Troglodytidae	9	10	12	11	9	13	15	15	11	10	8	6
Mimidae	13	12	11	12	14	10	12	20	13	14	14	11
Turdidae	36	39	41	46	39	29	44	79	72	50	58	36
Sylviidae	+	1	1	1	2	1		1				
Motacillidae												
Bombycillidae	5	17	2				+			3	5	9
Sturnidae	21	18	18	8	16	8	13	19	4	14	5	3
Vireonidae	79	83	74	68	67	57	66	48	39	39	46	29
Parulidae	168	191	129	108	95	90	82	80	57	60	78	91
Ploceidae	1	1	+	1	1	+				1	+	
Icteridae	14	10	6	5	7	8	6	6	12	10	4	43
Thraupidae	14	12	9	6	6	5	6	7	7	3	3	2
Fringillidae	110	113	90	100	83	67	92	98	104	94	88	93
Total	582	619	518	478	452	389	439	489	417	408	408	406

TABLE 2 (*continued*)

	September			October			November			December		
	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4	5–14	15–24	25–4
Cuculidae	1	+										
Apodidae	11	182	60	5								
Trochilidae	3											
Picidae	12	22	39	32	21	33	24	25	22	30	30	32
Tyrannidae	11	10	7	3	1	1						
Alaudidae			3	4	1	6	2			3	+	
Hirundinidae		1										
Corvidae	17	29	84	63	47	60	46	30	29	35	47	34
Paridae	44	27	31	32	36	28	31	26	23	37	26	32
Sittidae	1	2	5	7	5	5	7	7	7	8	8	7
Certhiidae			2	3	6	7	5	5	4	2	2	4
Troglodytidae	7	6	7	7	4	9	5	6	5	5	4	3
Mimidae	9	13	13	11	5	4	4	4	2	3	2	3
Turdidae	32	35	49	79	83	233	50	36	17	25	17	3
Sylviidae		+	1	38	54	91	31	24	22	39	23	36
Motacillidae		+		2	3	3	+				+	
Bombycillidae	13	21	10	8	6	110	7	1	4	6	7	17
Sturnidae	4	20	15	26	11	64	16	10	13	15	52	4
Vireonidae	27	13	2	1	1	2						
Parulidae	103	83	88	83	63	78	23	12	4	9	9	5
Ploceidae		1	4	2	4	2				1		
Icteridae	16	11	17	45	29	737	163	44	7	3	3619*	1
Thraupidae	3	4	4	+								
Fringillidae	97	149	212	304	464	1 107	454	455	343	451	393	360
Total	411	629	653	755	844	2 080	868	685	502	672	4239*	541

* The high figure for the period December 15-24 was due to a very late Grackle flight of major proportions in 1944.

WINTERING BIRD POPULATIONS

The Refuge bird populations in winter were relatively static. Migration was almost at a standstill at this season and any variation in population was largely due to the local wandering of wintering birds in search of food. At this time the population was in a state of equilibrium between pressures of the southward fall migration, and the northward spring migration. During most years this condition prevailed throughout January, and to a slightly less degree during the last ten days in December and the first ten days of February.

Food supply was of paramount importance at this season. The annual crop of winter foods varied considerably from year to year, and this was reflected in a considerable yearly variation in wintering bird populations (see Table 3, and Figure 6). Years with a bountiful supply of seeds, fruits, and mast could generally be correlated with a high population of omnivorous and herbivorous species which made up the bulk of the wintering birds present. Correspondingly, a low yield of these foods was associated with a reduced wintering bird population.

Trends in yearly abundance of certain birds, notably the Golden-crowned Kinglet, White-breasted Nuthatch, and Red-breasted Nuthatch appeared to parallel each other, but were apparently entirely independent of the population trends of most of the other wintering species. In fact, the high populations of these three species were usually found during years when most of the other species were represented by comparatively low populations, and vice versa.

Certain "half-hardy" species that are near the northern limits of their wintering range often showed greater yearly fluctuations in numbers than those which typically range farther north. This group would include the following: Yellow-bellied Sapsucker, Hermit Thrush, Ruby-crowned Kinglet, Rusty Blackbird, Eastern Towhee, Savannah Sparrow, Field Sparrow, Fox Sparrow, and Swamp Sparrow. Still other species of even more southerly winter distribution were of casual occurrence only. These included the Pigeon Hawk, Brown Thrasher, American Pipit, and Vesper Sparrow.

A few birds, including the Red-headed Woodpecker, White-breasted Nuthatch, Red-breasted Nuthatch, and Pine Siskin were very irregular in their winter occurrence and were frequently either absent or extremely rare. Certain others were fairly regular in small numbers but were quite erratic in their occurrence on the Refuge from day to day. These included the Robin, Cedar Waxwing, Red-wing, Grackle, Cowbird, and Purple Finch.

More than half of the wintering population was made up of winter resident species, the remainder being permanent residents. Birds belonging to the family *Fringillidae* were usually predominant in numbers, comprising from 40 to 60 percent of the total population each year. Other land birds present in fairly large numbers were quail, doves, woodpeckers, crows, jays, titmice, and kinglets. Altogether 84 species of birds have been recorded on the Refuge during the winter period.

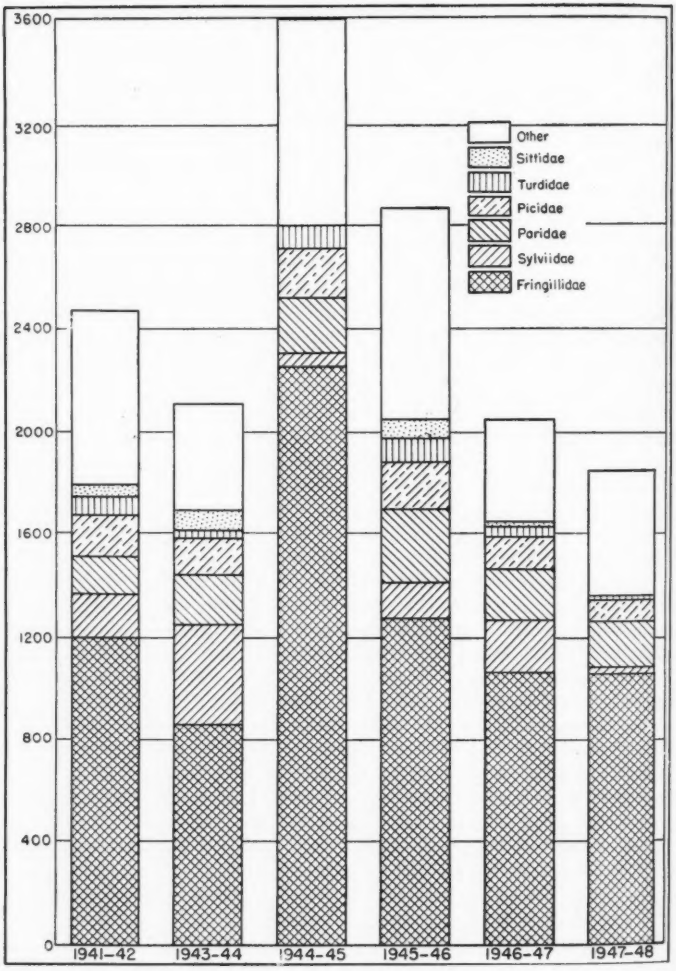

Fig. 6.—Histogram showing yearly variation in wintering populations (Data taken from winter surveys)

TABLE 3.—Total number of individuals of each species recorded during extensive winter censuses and winter surveys. Species are arranged in order of their abundance based on averages of the two extensive winter censuses.

	Extensive Winter Census		Winter Surveys						
	Jan. 1944	Jan. 1945	Dec. 23 1941	Dec. 23 1943	Dec. 29 1944	Dec. 28 1945	Dec. 26 1946	Jan. 16 1948	Jan. 14 1949
Slate-colored Junco	811	1612	676	449	1283	535	561	569	409
Tree Sparrow	381	705	204	151	228	337	71	177	124
American Goldfinch	193	536	91	120	239	98	121	9	92
White-throated Sparrow	34	456	84	11	233	111	160	90	64
Tufted Titmouse	223	254	53	125	135	180	99	57	61
Golden-crowned Kinglet	414	9	170	380	46	144	198	24	100
Carolina Chickadee	198	108	92	79	82	107	105	119	116
Mourning Dove	133	119	49	26	157	72	16	94	82
Blue Jay	36	199	144	6	123	162	21	23	20
Downy Woodpecker	120	111	42	71	69	84	73	50	38
Bob-white	130	78	28	42	33	40	26	23	4
Cardinal	59	141	53	53	61	65	50	43	60
Song Sparrow	63	114	53	35	91	82	66	86	23
American Crow	66	76	102	115	200	151	74	67	153
Myrtle Warbler	22	106	215	20	55	14	38	0	196
Brown Creeper	66	54	24	22	13	21	10	20	31
Field Sparrow	43	76	3	35	57	23	15	45	15
Flicker	26	91	75	24	53	44	15	6	30
Red-bellied Woodpecker	40	52	32	27	38	30	20	10	21
White-breasted Nuthatch	73	7	16	49	0	52	7	0	9
Starling	19	55	36	9	18	244	111	29	11
Carolina Wren	48	24	6	15	10	21	26	40	9
Hermit Thrush	13	54	8	3	34	27	3	14	2
Eastern Bluebird	34	31	52	32	33	68	36	2	16
Red-breasted Nuthatch	63	0	37	25	0	22	7	0	1
Hairy Woodpecker	27	23	9	13	13	22	15	18	8
Winter Wren	20	29	9	13	19	15	15	10	6
Eastern Meadowlark	32	14	8	28	16	1	0	2	1
Purple Finch	5	39	10	0	23	7	7	5	1
Barred Owl	25	18	3	5	3	6	0	2	2
Red-wing	32	1	0	2	1	0	0	51	1
Swamp Sparrow	11	22	4	9	16	12	12	44	8
Yellow-bellied Sapsucker	7	24	4	3	11	3	3	4	0
Cedar Waxwing	0	31	5	0	83	0	0	0	1
English Sparrow	12	19	17	12	12	22	23	30	2
Turkey Vulture	14	14	7	30	17	1	24	19	25
Eastern Towhee	0	28	11	0	26	2	0	0	0
Horned Lark	12	10	1	0	1	0	0	0	0
Robin	2	20	15	0	25	5	1	0	157

TABLE 3.—(*continued*)

	Extensive Winter Census		Winter Surveys						
	Jan. 1944	Jan. 1945	Dec. 23 1941	Dec. 23 1943	Dec. 29 1944	Dec. 28 1945	Dec. 26 1946	Jan. 16 1948	Jan. 14 1949
Mockingbird	7	11	4	8	8	14	5	7	7
Red-shouldered Hawk	10	6	2	4	2	11	5	5	2
Red-tailed Hawk	4	5	1	3	5	3	4	3	2
Pileated Woodpecker	3	3	1	1	4	3	0	4	2
Ruby-crowned Kinglet	1	5	0	2	4	0	3	1	23
Cooper's Hawk	1	4	0	1	1	2	2	2	1
Cowbird	5	0	0	0	0	0	0	3	0
Savannah Sparrow	1	3	0	0	0	0	0	3	0
Marsh Hawk	1	2	0	1	3	3	0	3	0
Horned Owl	1	1	1	0	0	1	0	0	0
Grackle	0	2	3	41	2	0	0	1	0
Wood Duck	1	0	1	0	0	0	0	0	0
Sparrow Hawk	1	0	0	1	1	0	0	2	0
Belted Kingfisher	1	0	0	1	0	0	0	0	0
Red-headed Woodpecker	0	1	1	0	0	0	0	0	0
Vesper Sparrow	1	0	0	0	0	0	0	0	0
Fox Sparrow	1	0	10	0	4	1	3	0	0
Mallard	0	0	0	1	0	0	0	3	0
Black Duck	0	0	0	0	0	0	0	0	4
American Merganser	0	0	0	6	0	0	0	0	58
Black Vulture	0	0	0	0	1	0	0	0	3
Sharp-shinned Hawk	0	0	1	0	0	0	1	1	1
Bald Eagle	0	0	0	0	0	0	3	0	3
Pigeon Hawk	0	0	0	0	1	0	0	0	0
Wilson's Snipe	0	0	0	0	0	0	0	0	1
Gull (sp.)	0	0	0	0	0	0	0	0	3
Screech Owl	0	0	0	0	0	1	0	0	0
Rusty Blackbird	0	0	0	0	0	1	0	18	1
Pine Siskin	0	0	2	0	0	2	8	0	0
Total	3546	5403	2745	2108	3599	2872	2048	1838	2010
No. of individuals per 100 acres	134	203							

Water birds were quite rare and irregular during the winter. This was due to the periodic freezing over of the lakes and ponds and the scarcity of food in the Patuxent River. Occasionally when the lakes and ponds were open, small flocks of ducks or mergansers appeared for short intervals, and during mild winters the Belted Kingfisher was sometimes seen.

Predatory birds were fairly constant in numbers from year to year, the more important species being the Red-shouldered Hawk, Red-tailed Hawk, Cooper's Hawk, and Barred Owl. Marsh Hawks and Horned Owls were present in very small numbers, and occasionally the Sparrow Hawk occurred. All other birds of prey were very rare and irregular. Turkey Vultures

occurred fairly commonly throughout the winter, but Black Vultures were rarely seen.

Species which were recorded on the Refuge during the winter (hiemal period, December 20 to February 10) but which were not observed on the extensive winter censuses or winter surveys, were: Canada Goose, Green-winged Teal, Redhead, Buffle-head, Hooded Merganser, Red-breasted Merganser, American Rough-legged Hawk, Herring Gull, Ring-billed Gull, *Killdeer, *Woodcock, Fish Crow, Catbird, Brown Thrasher, *American Pipit, and Redpoll. (Those marked with asterisks were early or late migrants.)

POPULATION CHANGES BY MONTH (January to June, inclusive)

January.—January* averages the coldest month of the year. Heavy rain or snowstorms sometimes occur. A storm in 1944 (2.49 inches of rain) caused a heavy flood in the bottomland, slightly exceeding the crest caused by a 3.46-inch rainstorm of the previous October. On the average, five or six inches of snow fell, the extremes being 3.5 and 6.2 inches.

January Climatic Data

Mean temperature: 33.6°.
Maximum monthly temperatures: 56° to 74°.
Minimum monthly temperatures: –4° to 10°.
Mean maximum daily temperatures: 39° to 51°.
Mean minimum daily temperatures: 20° to 30°.
Mean precipitation: 3.57 inches.
Monthly precipitation extremes: 1.84 inches to 3.83 inches.

Vegetation in general was in a dormant state during January. Most of the trees, shrubs, and vines were devoid of leaves. However, a few evergreen species, such as the pines, Red-cedar (*Juniperus virginiana*); Holly (*Ilex opaca*); Mountain-laurel (*Kalmia latifolia*); and Japanese Honeysuckle (*Lonicera japonica*), furnished excellent wildlife cover against predators and the elements. Herbaceous vegetation was largely withered and partly broken down, although the stalks of many of the coarser weeds and grasses remained standing. The supply of fruits and seeds of the plants which furnish the greater part of the winter food for wildlife was reduced quite rapidly at this time due to intensive use. On occasional warm days a few insects were seen flying about and newly-formed webs of spiders sometimes appeared. Much of the landscape presented a rather dreary and barren appearance, due in part to the drab grays and browns which predominated in the color scheme of the vegetation.

The Patuxent avifauna during January was composed almost entirely of the regular wintering population (see pages 279-283). However, during

* The weather data used in these monthly summaries are based on weather station records from Bell, Maryland, three miles south of the Refuge. They cover the period 1943-47, except for the mean temperature and mean precipitation which are derived from a 26-year period ending in 1946. The temperatures are given in the Fahrenheit scale.

the last few days of the month the northward Horned Lark migration generally began, and rarely, during unusually early years, the first Woodcock and Killdeer appeared. The appearance of these two species two or three weeks ahead of their usual arrival time occurred when the ground was bare and when warm southerly winds had raised temperatures into the high sixties or low seventies for several consecutive days at the end of the month. The only January records of diving ducks (except for the American Merganser which is widely distributed on all inland bodies of open water) were made on January 3, 1947, during a two-day spell of drizzle and fog accompanied by light northeast winds. The Redhead, Red-breasted Merganser, and Buffle-head were recorded at this time, the latter remaining through the sixth of the month.

February.—Next to January, this is the coldest month of the year; and in some seasons, such as the winter of 1946-47, both the lowest mean monthly temperature and the coldest day of the season occurred in February. The only heavy rain during the period 1943-47 fell on February 11, 1943 (1.08 inches); and the heaviest snow storm occurred on February 20-21, 1947, when 1.33 inches (melted) were recorded. On the average, five or six inches of snow (unmelted) fell in February each year, the extremes being 1.0 and 12.5 inches.

February Climatic Data

Mean temperature: 35.3°.
Maximum monthly temperatures: 57° to 73°.
Minimum monthly temperatures: 3° to 11°.
Mean maximum daily temperatures: 43° to 51°.
Mean minimum daily temperatures: 18° to 25°.
Mean precipitation: 2.89 inches.
Monthly precipitation extremes: 1.68 inches to 3.31 inches.

The vegetation showed the first signs of approaching spring. Skunk-cabbages (*Symplocarpus foetidus*) usually began blooming in early February, and by the middle of the month they were in full bloom quite generally. At this time the flowering buds of Prairie Willow (*Salix humilis*) often matured, and in certain fields and clearings the inconspicuous Chickweed (*Stellaria media*), Birds-eye Speedwell (*Veronica persica*), and Whitlow-grass (*Draba verna*) were in flower. The tassels of Alder (*Alnus serrulata*), and Hazelnut (*Corylus americana*) became noticeably lengthened, and by the end of the month were shedding their pollen. The axillary leaf buds of Elderberry (*Sambucus canadensis*) were unsheathed by the middle of February, and the buds on many trees became noticeably swollen. Toward the end of February the large, bright green leaves of Skunk-cabbage were usually conspicuous in many of the swamps.

Insects and other animals were seen with gradually increasing frequency. Several species of flies (*Diptera*) became more numerous; moths (*Heterocera*) were occasionally attracted by lights at night; and Mourning-cloak Butterflies (*Nymphalis antiopa*) and Commas (*Polygonia comma*) were sometimes seen in the woods on sunny days. In late February earthworms

(*Annelida*) generally appeared at the surface of the ground following heavy rains; while the high notes of Spring Peepers (*Hyla crucifer*) and Swamp Tree Frogs (*Pseudacris nigrita*) were often heard in a steady chorus, occasionally joined by the guttural calls of the Wood Frog (*Rana sylvatica*).

The Horned Lark migration continued through the first three weeks of February. By the 20th, the greater part of the Red-tailed Hawk population had left the area. The main wave of early migrating species, however, began during the last half of the month, although occasional migrating individuals of the species concerned were also seen during the first half. The characteristic species of this first wave were:

(February 15-March 25)*

Whistling Swan	Fish Crow
Canada Goose	Robin
Mallard	Eastern Bluebird
Black Duck	Red-wing
Pintail	Grackle (both Purple and Bronzed)
Wood Duck	Cowbird
Woodcock	Fox Sparrow
Killdeer	Song Sparrow
American Crow	

Weather conditions had a major influence on the periods of migration. During mild winters most of these species arrived much earlier than usual, while during years with cold or adverse weather conditions, the migration was delayed two or three weeks. The geese and ducks were generally noted during periods of thaw, particularly when these were accompanied by cloudy weather, light rain, and winds from the south or southeast. No flights of diving ducks were noted, possibly due to the lack of severe easterly storms in February.

March.—Although March is supposedly noted for its wind, local records do not show it to be windier than the months preceding or following it. Four March rainstorms yielded between 1.0 and 1.52 inches of rain each, causing light to moderate floods in the bottomland. Light snow flurries occurred each year except 1945, generally in the first half of the month. A very heavy snow storm in March 1942 caused considerable damage to trees; the results of this storm are still evident. March 1945 and March 1946 were respectively the second and third warmest in the history of the Baltimore Weather Bureau, being exceeded only in 1921; by contrast, March 1947 was the sixth coldest.

March Climatic Data

Mean temperature: 43.9°.	Mean minimum daily temperatures: 24° to 37°.
Maximum monthly temperatures: 70° to 89°.	Mean precipitation: 3.56 inches.
Minimum monthly temperatures: 0° to 22°.	Monthly precipitation extremes: 1.14 inches to 5.87 inches.
Mean maximum daily temperatures: 50° to 70°.	

* These dates represent the migration period for the majority of individuals of the species listed.

Alder, Hazelnut, Prairie Willow, and Silver Maple (*Acer saccharinum*) were in full bloom in early March, and by the middle of the month these were joined by Red Maple (*Acer rubrum*) and American Elm (*Ulmus americanus*). By late March the forest floor on the bottomland was rapidly turning green from the dense growth of seedlings and sprouts from one to three inches high. At the same time some of the showy woodland spring flowers started to bloom, including Bloodroot (*Sanguinaria canadensis*), Springbeauty (*Claytonia virginica*), Yellow Adders-tongue (*Erythronium americanum*), Pepper-root (*Dentaria laciniata*), and Trailing-arbutus (*Epigaea repens*). In the bottomland, Hornbeam (*Carpinus caroliniana*) came into bloom and the bright lemon-yellow flowers of Spicebush (*Lindera benzoin*) showed themselves, contrasting pleasingly with the red patches produced by the flowering Red Maples. In the orchards, Pears (*Pyrus communis*) and Peaches (*Prunus persica*) started to bloom and in some of the fields and clearings, the flowers of Dandelion (*Taraxacum officinale*), Ground-ivy (*Nepeta hederacea*) and Shepherds-purse (*Capsella bursa-pastoris*) had appeared.

During March the insect population was slowly increasing, and many of the cold-blooded vertebrates became more conspicuous. The Spring Peeper, Swamp Tree-frog, and Wood Frog were at the peak of their breeding cycle, and were often heard singing in chorus, almost incessantly. Spotted Salamanders (*Ambystoma maculatum*) were also active, and their spermatophores and egg masses were frequently found in the bottomland pools. Toward the last of the month the first Pickerel Frogs (*Rana palustris*), Leopard Frogs (*Rana pipiens*), and American Toads (*Bufo americanus*) were frequently heard calling, and the first snakes, lizards, and turtles had appeared.

Most of the wintering birds maintained their numbers throughout March. Tree Sparrows, however, began to decrease shortly after the first week, and by the end of the month nearly all had departed.

The second major wave of migrants generally made its appearance around March 10. The characteristic species are listed as follows:

(March 10-April 25)

Pied-billed Grebe
Great Blue Heron
Baldpate
Ring-necked Duck
Lesser Scaup Duck
American Golden-eye
Buffle-head
Hooded Merganser
American Merganser
Bald Eagle
Sparrow Hawk
Wilson's Snipe
Barn Owl
Belted Kingfisher
Flicker
Eastern Phoebe
American Pipit
Loggerhead Shrike
Pine Warbler
Eastern Meadowlark
Rusty Blackbird
Purple Finch
Savannah Sparrow
Vesper Sparrow
Field Sparrow

During late March, a somewhat smaller wave of migrants appeared. The species involved are listed as follows:

(March 25-May 1)

Horned Grebe
American Bittern
Blue-winged Teal
Ruddy Duck
Sharp-shinned Hawk
Osprey
Pigeon Hawk
Yellow Palm Warbler
Chipping Sparrow

Weather was still a very important factor in the determination of the migration periods of many species. In 1945, the maximum temperatures from March 16 through March 21 averaged 83.5°; for the next five days they were in the low seventies; then for the remaining five days of the month they ranged from 81° to 89°, averaging 85°. This March was not only the second warmest in the history of the Baltimore Weather Bureau, but in addition was warmer than a normal April. Because of this, many species which normally arrive in April, made their first appearance in late March, as much as two weeks or more earlier than usual. The most interesting arrival dates during this period were: Tree Swallow, March 22; Henslow's Sparrow, March 24; Purple Martin, March 25; Whip-poor-will, March 27; Louisiana Water-thrush, March 28; and Blue-gray Gnatcatcher, March 30. Of the species which normally arrive from the south in March, 71 percent were recorded earlier in 1945 than in any other year.

April.—The average precipitation in April was slightly higher than in any other month during winter or spring. The greatest daily rainfall occurred on April 19, 1943, when 1.26 inches fell. Snow flurries occurred as late as April 15 in 1943, but in the majority of years no snow was recorded during the month.

April Climatic Data

Mean temperature: 52.6°.
Maximum monthly temperatures: 81° to 89°.
Minimum monthly temperatures: 17° to 24°.
Mean maximum daily temperatures: 65° to 72°.
Mean minimum daily temperatures: 35° to 43°.
Mean precipitation: 3.84 inches.
Monthly precipitation extremes: 1.87 to 3.51 inches.

During the first three weeks of April the showy bottomland forest "spring flowers" were at their peak and formed a colorful mantle over the forest floor. Spring-beauties and Yellow Adders-tongue were found in profusion and many other species were commonly associated with them. During this same period Bluets (*Houstonia caerulea*), and Arrow-leaf Violets (*Viola sagittata*) were found in bloom in many of the fields and clearings; Trailing-arbutus in the upland woods; and Golden-club (*Orontium*

aquaticum) in the flood plain swamps. Splashes of white appeared in the upland forests as Shadbush (*Amelanchier arborea*) came into flower, and in upland swamps the light green fronds of Cinnamon Fern (*Osmunda cinnamomea*) were emerging from the ground.

The true vernal period began about the middle of April. At this time the first lawn-cutting was necessary, and the forest canopy took on a yellowish-green aspect which gradually deepened in intensity as more and more leaves burst out with each succeeding day. The bottomland forest and swamp forests were well ahead of the upland forests in this respect, largely because of the greater abundance of Tulip-tree (*Liriodendron tulipifera*) and a few other species which were among the first to unfurl their leaves.

During the last half of April, many different species of trees came into full bloom, including River Birch (*Betula nigra*), Sycamore (*Platanus occidentalis*), Sassafras (*Sassafras albidum*), Apple (*Malus pumila*), Flowering Dogwood (*Cornus florida*), Beech (*Fagus grandifolia*), and most of the Oaks (*Quercus* spp.). For a short period much of the upland oak forest assumed a brownish aspect because of the numerous oak tassels. Among the shrubs Highbush Blueberry (*Vaccinium corymbosum*) and Blackhaw (*Viburnum prunifolium*) were in full bloom, while at the same time numerous additional herbaceous species had appeared.

By the middle of April insects had become numerous and continued to show a rapid increase until the end of the month. The American Toad, Pickerel Frog, and Leopard Frog were at the height of their breeding activities, and toward the end of April the first Cricket Frogs (*Acris crepitans*), Tree Toads (*Hyla versicolor*), and Fowler's Toads (*Bufo fowleri*) were usually heard singing. Black Racers (*Coluber constrictor*), Pilot Black Snakes (*Elaphe obsoleta*) and other species of snakes had become much more conspicuous, and at the same time the various species of turtles and lizards were seen with much greater frequency.

Many of the winter resident birds left for the north during April. A marked reduction in the number of Juncos became evident around April 10, and by the end of the month this species had become quite rare. Golden-crowned Kinglets showed an abrupt decrease about the middle of the month and by the end of the third week had largely disappeared. The latest Winter Wrens usually left during the last week in April, while Brown Creepers showed an abrupt decrease at the end of the first week and had all departed by the end of the month. By April 20 a general decline in the numbers of Marsh Hawks was also noticeable.

Four fairly distinct migration waves usually occurred on the Refuge during April. The characteristic species of each of these are listed as follows:

(April 5-May 5)

Tree Swallow
Purple Martin
Hermit Thrush
Blue-gray Gnatcatcher
Ruby-crowned Kinglet
Myrtle Warbler
American Goldfinch
Eastern Towhee
Swamp Sparrow

(April 12-May 10)

Common Loon
Green Heron
Broad-winged Hawk
Greater Yellow-legs
Whip-poor-will
Chimney Swift
Bank Swallow
Rough-winged Swallow
Barn Swallow
Brown Thrasher
Louisiana Water-thrush
Henslow's Sparrow
White-throated Sparrow

(April 20-May 18)

Spotted Sandpiper
Lesser Yellow-legs
Eastern Kingbird
Blue Jay
House Wren
Blue-headed Vireo
Black and White Warbler
Parula Warbler
Prairie Warbler
Yellow-throat
American Redstart
Grasshopper Sparrow

(April 27-May 20)

Solitary Sandpiper
Crested Flycatcher
Catbird
Wood Thrush
White-eyed Vireo
Yellow-throated Vireo
Red-eyed Vireo
Prothonotary Warbler
Nashville Warbler
Yellow Warbler
Black-throated Green Warbler
Oven-bird
Hooded Warbler
Orchard Oriole
Scarlet Tanager

April was one of the most interesting months to observe bird migration, not only because of the return of a large percentage of the nesting and transient passerine species, but also because of the spring flights of hawks, ducks, and loons. The migratory movements of most of these birds were largely governed by the weather. In 1945 the high temperatures of March continued through April; the vegetation retained much of its head start, and a large proportion (33%) of the earliest April arrival dates were recorded. The arrival of many of the insectivorous species, including most of the warblers and vireos, was correlated with the time of leafing-out of many of the forest trees. On the Refuge the bottomland forest was well ahead of the upland forests in this leafing-out process, and it is here where most of these species were found during April. The Red-eyed Vireo was almost entirely restricted to this habitat early in the season, although later during the late spring and summer this species was found commonly in all of the deciduous forest types.

The only storm in April which caused unseasonable arrivals was an intense low pressure area which originated in Kansas and moved up the Mississippi Valley on April 5-6, 1947. Winds over 50 miles per hour swept the states immediately east of the Mississippi River, and numerous unprecedented arrival dates were recorded as far east as West Virginia. Being at the very edge of the area affected by this storm, only three early arrivals were noted on the Refuge: Chimney Swift and Whip-poor-will on April 6 and an adult male Orchard Oriole on April 7. Of these, only the oriole was weeks ahead of its normal arrival date, no other being seen for 22 days.

The appearance of diving ducks was usually correlated with light to moderate northeasterly winds, generally accompanied by light rain or drizzle. A few flights occurred on southerly or southwesterly winds, but except for the record of the largest flock of Ring-necked Ducks (43) on April 4, 1947, such flights were recorded on days when the sky was heavily overcast.

April was the month for spring hawk flights although many of the larger Buteos passed through before this. Daily counts of more than 100 hawks were made on only two dates: 200 birds were counted between 12:50 P.M. and 2:30 P.M. (175 in the first 40 minutes) on April 16, 1944, and 224 between 8:15 A.M. and 3:30 P.M. on April 26, 1945. It is interesting to note that weather conditions were quite different on these two days. On the former occasion, winds were light southwesterly for the first 40 minutes, then became variable and shifted to the northwest while the sky became heavily overcast; the temperature was 70°. Eight species were recorded during the flight as follows: 171 Broad-winged Hawks, 13 Sharp-shinned Hawks, 6 Sparrow Hawks, 4 Cooper's Hawks, 3 Ospreys, and 1 each of the Red-tailed Hawk, Red-shouldered Hawk, and Pigeon Hawk. The flight of April 26 took place on a 15 to 20-mile-an-hour southeasterly wind associated with an energetic low pressure area moving up the Ohio Valley; cumulus clouds half filled the sky, and the temperature was 75°. During this flight the following hawks were recorded: 105 Sharp-shinned Hawks, 43 Ospreys, 30 Broad-winged Hawks, 24 Cooper's Hawks, 7 Sparrow Hawks, 6 Red-shouldered Hawks, 4 Bald Eagles, 3 Red-tailed Hawks, and 2 Duck Hawks.

May.—Warm weather arrived in May and stayed well into September. Killing frosts were comparatively rare, but very destructive in the years when they did occur. The latest killing frosts occurred on May 2 in 1943 and 1945. Nearly every year, at least one heavy rainstorm occurred in May, although in most cases only minor floods resulted and little damage was done to ground-nesting birds on the flood-plain of the Patuxent River. On six occasions during the past five years over one inch of rain fell in 24 hours, with the highest amount, 2.02 inches, occurring on May 1, 1947. Three-day rains on May 26-28, 1946, and May 12-14, 1946 yielded totals of 2.88 and 2.02 inches respectively.

May Climatic Data

Mean temperature: 63.1°.
Maximum monthly temperatures: 88° to 92°.
Minimum monthly temperatures: 24° to 38°.
Mean maximum daily temperatures: 75° to 83°.
Mean minimum daily temperatures: 47° to 54°.
Mean precipitation: 3.67 inches.
Monthly precipitation extremes: 1.19 inches to 6.97 inches.

By the end of the first week the leaves of the forest trees were almost entirely out with the exception of a very few species such as the ashes (*Fraxinus* spp.) and Blackgum (*Nyssa sylvatica*). However, the forest canopy still maintained the yellowish-green aspect of spring, and it was not until about two weeks later that the darker green of summer was assumed. Many of the conspicuous bottomland forest "spring flowers" which were so prevalent during April were still in bloom during the first week in May but disappeared soon after. During May, the vegetative aspect was changing almost constantly, as an ever-increasing number of woody and herbaceous species gradually succeeded each other in passing through their respective flowering periods.

Insectivorous birds were now found to comprise the great majority of the migrants. During the early part of the month the bulk of these migrants consisted of species that were resident on the Refuge, while later on, transients that nest far to the north predominated.

Four fairly distinct waves of migrants were generally discernible during May. The characteristic species of each of these are listed as follows:

(May 2-May 22)

Least Sandpiper
Ruby-throated Hummingbird
Acadian Flycatcher
Least Flycatcher
Cliff Swallow
Veery
Worm-eating Warbler
Golden-winged Warbler
Blue-winged Warbler
Black-throated Blue Warbler
Blackburnian Warbler
Chestnut-sided Warbler
Northern Water-thrush
Kentucky Warbler
Yellow-breasted Chat
Bobolink
Baltimore Oriole
Summer Tanager
Rose-breasted Grosbeak
Indigo Bunting
White-crowned Sparrow
Lincoln's Sparrow

(May 6-May 25)

Yellow-billed Cuckoo
Black-billed Cuckoo
Nighthawk
Eastern Wood Pewee
Olive-backed Thrush
Cedar Waxwing
Magnolia Warbler
Cape May Warbler
Canada Warbler
Blue Grosbeak

(May 10-May 31)

Gray-cheeked Thrush
Tennessee Warbler
Bay-breasted Warbler
Black-poll Warbler
Wilson's Warbler

(May 20-June 5)

Yellow-bellied Flycatcher
Alder Flycatcher
Olive-sided Flycatcher
Mourning Warbler

The first week of May marked the peak of the spring migration as far as variety of species was concerned. Between 80 and 115 (May 3, 1947) species were usually seen in one day afield at this time. Good flights often occurred during periods of low barometric pressure preceded by warm nights with southerly or southwesterly winds. A prolonged spell of cold weather accompanied by northerly winds was usually followed by a particularly fine migratory flight as soon as warm weather returned. The peak movements of spring migrants were generally over shortly after the middle of May, although in 1945, the coldest May in 10 years, many transients were still in evidence in the closing days of the month. That year temperatures in the thirties were general through the 12th, and recurred periodically through May 25.

Thus in a single spring (1945), opposite extremes in temperature conditions were recorded; the unseasonably warm weather during March and April caused early migrating species to arrive and depart unusually early, while the markedly cool weather of May served to retard the departure of many of the later migrants.

June.—Hot summer weather arrived with a vengeance in June, and for a three-month period temperatures frequently in the nineties could be counted upon. The number of heavy rains was low, only three June rains in five years registering over one inch at the Bell weather station. These three amounted to 3.22 inches, 1.72 inches, and 3.66 inches on June 22, 1945, June 8, 1947, and June 14, 1947, respectively. The most severe June flood of all was caused by the storm of June 2, 1946, which was comparatively light at Bell, Maryland (0.84 inch), but very heavy in the Patuxent drainage basin to the west of the Refuge. The nearest weather station to the headwaters of the Patuxent River (Unionville, Frederick County), recorded 3.87 inches at this time.

June Climatic Data

Mean temperature: 72.2°.
Maximum monthly temperatures: 94° to 99°.
Minimum monthly temperatures: 36° to 53°.
Mean maximum daily temperatures: 83° to 89°.
Mean minimum daily temperatures: 57° to 65°.
Mean precipitation: 3.61 inches.
Monthly precipitation extremes: 1.82 inches to 6.60 inches.

A new array of plants burst into bloom during June. Many of the fields and clearings were now covered with an ever-increasing variety of colorful herbaceous plants in flower. The herbaceous flowers of the forests, however, were relatively inconspicuous at this time compared to the beautiful spring displays, but still included a considerable variety of plants. Ripe fleshy fruits became available for food for the first time. By the middle of June, Strawberries (*Fragaria virginiana*) and Shadbush fruit (*Amelanchier* spp.) were ripe, and by the end of the month the fruits of Blueberries (*Vaccinium* spp.) and Low-bush Blackberries (*Rubus* spp.) were available.

A few spring transients remained into June every year, the most fre-

quently recorded being the Spotted Sandpiper. Only one to three other species were noted per year, except in the phenomenally late season of 1945, when the first 10 days of June were colder than the average for May. The 11 species of migrants recorded between the first and eleventh (inclusive) of June, 1945, were: Spotted Sandpiper, Least Flycatcher, Olive-sided Flycatcher, Olive-backed Thrush, Gray-cheeked Thrush, Magnolia Warbler, Blackburnian Warbler, Black-poll Warbler, Mourning Warbler, Canada Warbler, and White-throated Sparrow. Transient species recorded during early June in other years, but not in 1945, were: Alder Flycatcher, Short-billed Marsh Wren, Warbling Vireo, Yellow Warbler, Baltimore Oriole, and Rose-breasted Grosbeak.

After the last of the late transients had departed for the north, the Refuge avifauna during June was composed almost entirely of the normal breeding population. Summer resident species made up a much larger proportion of this population than did the permanent residents. Occasional vagrant species were recorded from time to time, especially in the latter part of the month.

Breeding Bird Populations

Birds were more sedentary in their habits during the breeding season than at any other time. Activities connected with the care and protection of nests, mates, and territories necessarily restricted their movements. In most species, each pair of birds was largely confined to one rather definite territory from which all other individuals of the same species were excluded. Because of this it was possible through repeated censuses of the same area to obtain a fairly accurate count of the bird population. It was necessary however, to census each species at the height of its breeding season before a reliable count on the total bird population could be obtained.

Insects and other animal food made up the greater part of the diet of most birds during the breeding season. This source of food was nearly always ample at this time. Presumably, this constancy of food supply was one reason that relatively little yearly variation in breeding populations was noted. Most of the yearly variation that did occur was probably due to other factors such as habitat changes and severe climatic disturbances. The Black-billed Cuckoo and Cedar Waxwing were two species which frequently showed considerable yearly variation in their breeding populations; perhaps this may be partially accounted for by the fact that the Refuge is located near the southern limit of their breeding ranges.

The breeding population was made up of summer resident species which occurred on the Refuge only during the warmer months (migrating south for the winter), and permanent resident species which occurred regularly throughout the year. In 1943, roughly 82 percent of the total population was made up of summer resident species and 18 percent of permanent resident species. The insectivorous vireos (*Vireonidae*) and wood warblers (*Parulidae*) together comprised approximately 50 percent of the total breeding population in 1943, while the sparrows and finches (*Fringillidae*), which represent the predominant family during the winter, made up only 11

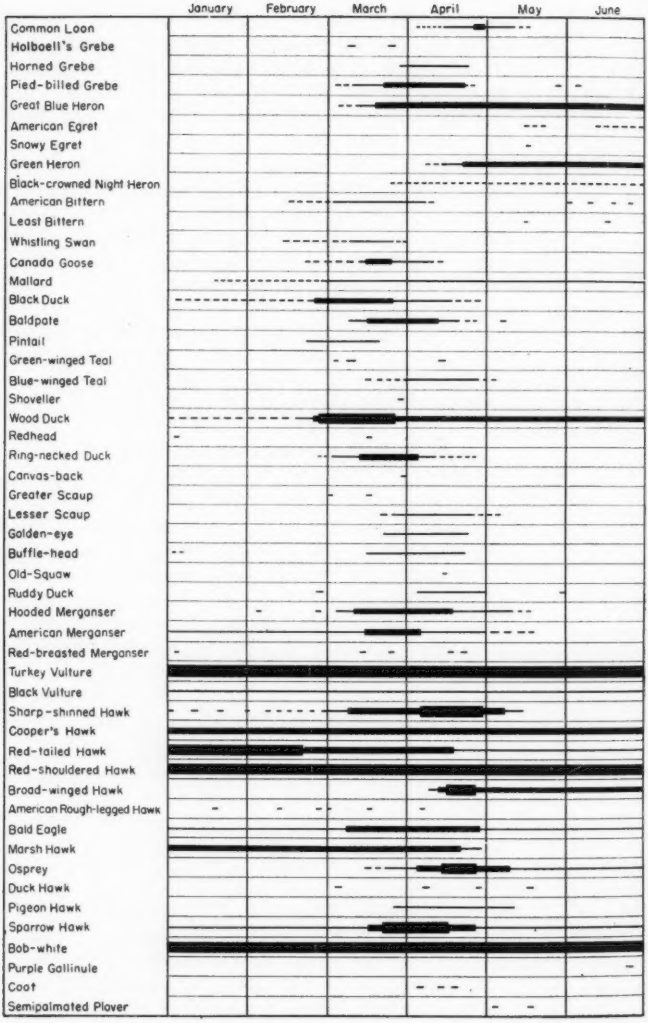

Fig. 7A.—Chart showing seasonal distribution and relative abundance of species recorded on the Refuge during the period January to June, inclusive. The occurrence of a species is shown by lines extending through the periods of residence. A solid line indicates regular occurrence while a broken line indicates irregular occurrence. The four widths of line correspond to the terms: rare, uncommon, common, and abundant. A few records were made after the chart was completed and are not included.

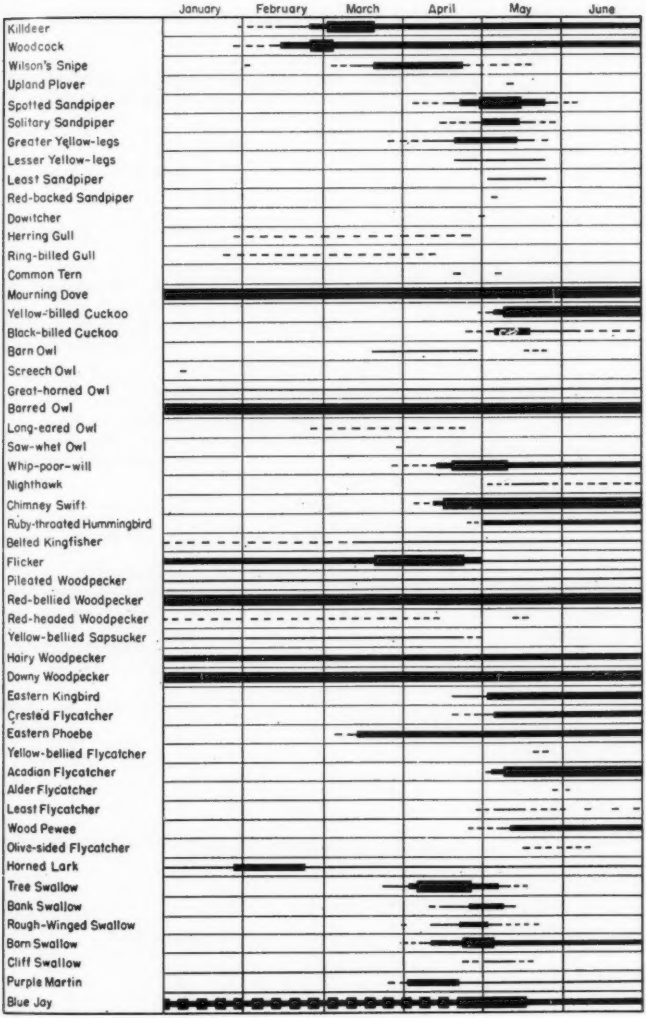

Fig. 7B.—See Fig. 7A for description

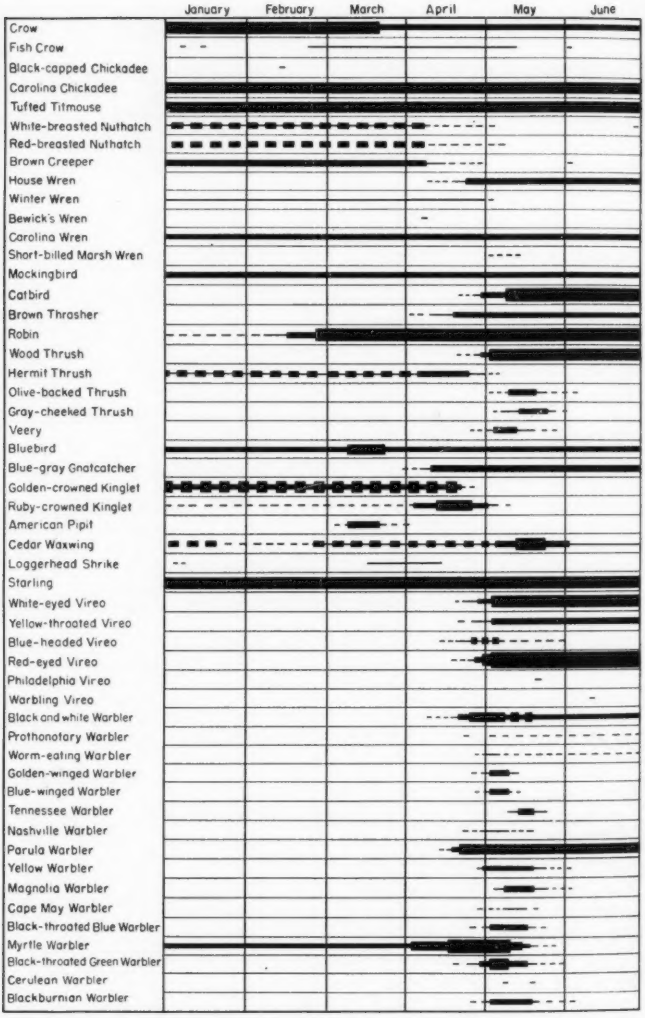

Fig. 7C.—See fig. 7A for description

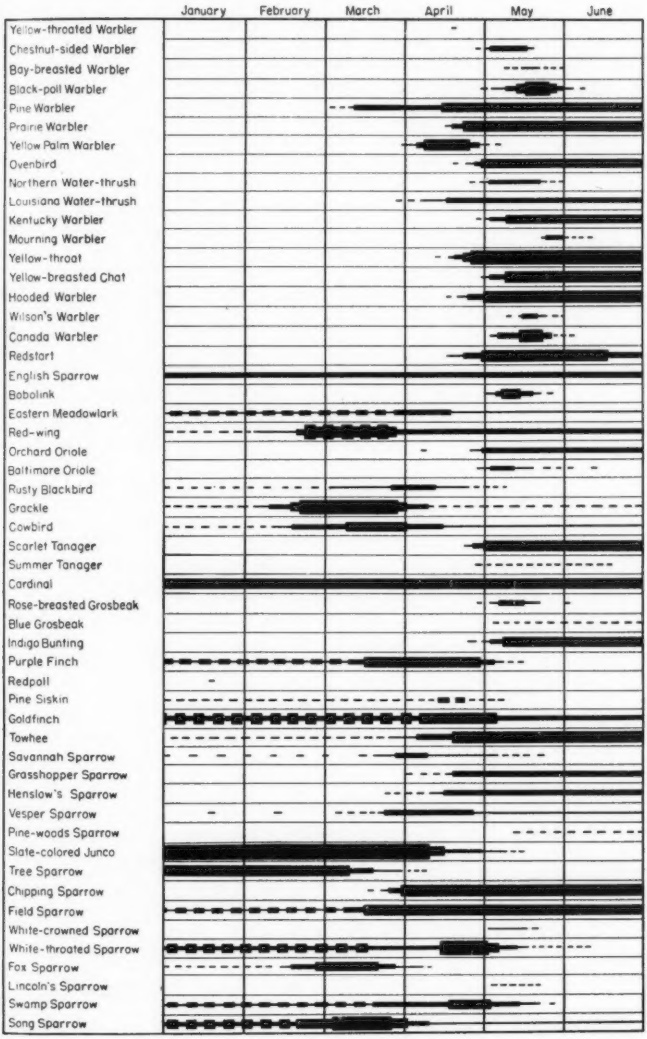

Fig. 7D.—See fig. 7A for description

percent of the total. Other groups present in fairly large numbers included the flycatchers (*Tyrannidae*), thrushes (*Turdidae*), tanagers (*Thraupidae*), titmice (*Paridae*), and the woodpeckers (*Picidae*). Water birds in general were rather scarce due to the paucity and small size of suitable feeding and nesting habitats. Raptores were generally slightly more common during the breeding season than in winter, the more common breeding species being the Barred Owl, Red-shouldered Hawk, Broad-winged Hawk, and Cooper's Hawk.

TABLE 4.—Approximate number of pairs of each species with established nesting territories on the Refuge during the breeding season of 1943. (Nests were located or adults observed feeding young for all species listed except those few preceded by asterisks.)

1. Red-eyed Vireo	908	43. American Crow	16
2. Yellow-throat	397	44. Whip-poor-will	15
3. Wood Thrush	290	45. Eastern Phoebe	15
4. American Redstart	275	46. Starling	15
5. Acadian Flycatcher	267	47. Eastern Kingbird	14
6. Scarlet Tanager	215	48. *Black-billed Cuckoo	12
7. Parula Warbler	205	49. Barred Owl	11
8. Oven-bird	202	50. Brown Thrasher	11
9. Kentucky Warbler	188	51. Grasshopper Sparrow	10
10. Tufted Titmouse	187	52. Barn Swallow	9
11. Hooded Warbler	186	53. Blue-gray Gnatcatcher	9
12. Prairie Warbler	151	54. Song Sparrow	9
13. Eastern Towhee	150	55. Turkey Vulture	7
14. Field Sparrow	145	56. Red-shouldered Hawk	6.5
15. Cardinal	131	57. Worm-eating Warbler	6
16. Catbird	125	58. Orchard Oriole	6
17. White-eyed Vireo	112	59. Mockingbird	5
18. Yellow-breasted Chat	91	60. Red-wing	5
19. Carolina Chickadee	85	61. Vesper Sparrow	5
20. Yellow-billed Cuckoo	75	62. Broad-winged Hawk	4.5
21. Red-bellied Woodpecker	69	63. Wood Duck	4
22. Ruby-throated Hummingbird	64	64. Killdeer	4
23. Eastern Wood Pewee	60	65. English Sparrow	4
24. Indigo Bunting	59	66. Green Heron	3
25. Downy Woodpecker	58	67. Cooper's Hawk	3
26. Chipping Sparrow	55	68. Eastern Meadowlark	3
27. Yellow-throated Vireo	50	69. Cowbird	3
28. Black and White Warbler	45	70. Belted Kingfisher	2
29. Carolina Wren	43	71. Flicker	2
30. Pine Warbler	39	72. Cedar Waxwing	2
31. Mourning Dove	32	73. *Prothonotary Warbler	2
32. Bob-white	25	74. *Henslow's Sparrow	2
33. Crested Flycatcher	25	75. Pileated Woodpecker	1.5
34. Blue Jay	25	76. Black Vulture	1
35. Robin	25	77. Red-tailed Hawk	1
36. American Goldfinch	25	78. Horned Owl	1
37. Louisiana Water-thrush	23	79. Horned Lark	1
38. Woodcock	22	80. *Nighthawk	0.5
39. House Wren	19		
40. Hairy Woodpecker	17	Total number of pairs	5,429
41. Eastern Bluebird	17		
42. Chimney Swift	16	Number of pairs per 100 acres	204

Other species that had established nesting territories on the Refuge during the period of this investigation but which were not present in 1943 are: Great Blue Heron, Mallard, Sparrow Hawk, Least Flycatcher, Short-billed Marsh Wren, Summer Tanager, and Blue Grosbeak. Actual nest records were obtained for all of these except the Short-billed Marsh Wren and Summer Tanager. These bring the total number of species nesting on the Refuge to 87 (nests found for 80 species, fledglings observed for one additional species). Purple Martins apparently attempted to nest on the Refuge on several occasions but were prevented from doing so by Starlings.

POPULATION CHANGES BY MONTH (July to December, inclusive)

July.—July was normally the hottest month of the year, though in some seasons June or August slightly exceeded it. Although rains of an inch or more frequently occurred in July, they ordinarily did not cause the Patuxent River to overflow its banks, since it was normally at a low level during mid-summer. The only severe flood was caused by the heavy rains of July 17-19, 1945, when the three-day total was 4.62 inches, and the greatest amount in one day, 3.64 inches.

July Climatic Data

Mean temperature: 75.7°.
Maximum monthly temperatures: 94° to 98°.
Minimum monthly temperatures: 45° to 51°.
Mean maximum daily temperatures: 85° to 90°.
Mean minimum daily temperatures: 61° to 64°.
Mean precipitation: 4.37 inches.
Monthly precipitation extremes: 2.33 inches to 12.26 inches.

The vegetative aspect during July was enhanced by the flowering of a considerable variety of plants, although most of the forest species were relatively inconspicuous. Many of the fields and clearings were dominated by the abundant white flowers of Daisy (*Chrysanthemum leucanthemum*), Wild Carrot (*Daucus carota*), Yarrow (*Achillea millefolium*), Flowering Spurge (*Euphorbia corollata*), and Fleabanes (*Erigeron ramosus* and *E. annuus*). The wildlife food supply increased during July by the ripening of fruit of high-bush blackberries (*Rubus* spp.), huckleberries (*Gaylussacia baccata* and *G. frondosa*), and Elderberries (*Sambucus canadensis*).

During July a large proportion of the local nesting birds left their territories and started to wander over the countryside in family groups or in mixed flocks with other species. The few that were still nesting at this time were composed chiefly of late nesters such as the Cedar Waxwing and Goldfinch, and of scattered pairs of certain other species which were attempting to raise second or third broods.

Three distinct migratory movements that became noticeable in July were the northward wandering of southern herons (including the American Egret, Little Blue Heron, and Snowy Egret), the southward migration of swallows, and the southward migration of Spotted and Solitary Sandpipers.

The movements of these three groups were not closely correlated with local weather conditions. Swallows and sandpipers arrived just as frequently during warm weather as following cold periods, and since the Refuge ponds were kept at controlled levels, local temperature and precipitation had little effect on their attractiveness to herons.

July temperatures sometimes were instrumental in controlling the migration of the Bobolink and Orchard Oriole. The Bobolink, which often did not appear until about August 20, was recorded on two exceptionally early dates: July 18, 1944, and July 22, 1942. On both of these days minimum temperatures were in the middle fifties, in sharp contrast to the warm weather of preceding days. The Orchard Oriole, first summer resident to leave for the south, was sometimes recorded in August, but just as frequently was not found after the 20th of July. In 1946, for instance, it was last noted on July 18, the third day of a cold spell (minimum temperature, 48°). In 1947 it was last recorded on the 19th; on the following morning the mercury had dropped to 59° at Bell, Maryland, and the climax of the ensuing cold snap came on the 24th, when the minimum temperature at Bell was 48°. At this time, light frosts were recorded in the mountains of western Maryland, and thereafter no Orchard Orioles were reported from the entire state, until the following spring.

August.—The mean temperature for August is only 2° cooler than the mean for July. Much of this difference resulted from the few cool nights which generally arrived toward the close of the month. Heavy rainstorms frequently occurred with the result that August had the highest average precipitation of any month. In 1944 a total of 4.68 inches of rain fell on August 2; an additional 1.50 inches fell on the following day, leaving a total of 6.18 inches for the one storm. This was the heaviest rainstorm in the period covered by this study.

August Climatic Data

Mean temperature: 73.6°.
Maximum monthly temperatures: 91° to 99°.
Minimum monthly temperatures: 41° to 52°.
Mean maximum daily temperatures: 83° to 92°.
Mean minimum daily temperatures: 58° to 64°.
Mean precipitation: 4.53 inches.
Monthly precipitation extremes: 0.74 inches to 6.65 inches.

An entirely new assortment of plants was in bloom during August. In some of the more moist forest types were found Wood Nettle (*Laportea canadensis*), Cardinal-flower (*Lobelia cardinalis*), and Tall Coneflower (*Rudbeckia laciniata*) to name only a few. Many of the fields and clearings were largely dominated by the flowering Early Goldenrods and Horseweed (*Erigeron canadensis*). Ripe fruits that were available for wildlife included Black Cherry (*Prunus serotina*), Fox Grape (*Vitis labrusca*), Arrow-wood (*Viburnum dentatum*), Pokeweed (*Phytolacca americana*), and Sassafras (*Sassafras albidum*).

Toward the end of August many flowers typical of late summer and

autumn began to appear in large numbers. These included several species of goldenrod (*Solidago* spp.), New York Ironweed (*Veronica noveboracensis*), Hawkweeds (*Hieracium* spp.), Golden Aster (*Chrysopsis mariana*), Common Ragweed (*Ambrosia artemisiifolia*), and various species of eupatorium (*Eupatorium* spp.), and Lespedeza (*Lespedeza* spp.). During the last week of August fall colors appeared in the foliage of several tree species. The bright red leaves on some of the Blackgums (*Nyssa sylvatica*) were especially noticeable, and frequently small trees and saplings of Sweetgum (*Liquidambar styraciflua*) were seen with leaves that were changing to a pleasing maroon.

With the exception of a very few late nesters, practically all of the birds had forsaken their nesting territories by this time, and were found wandering over large areas in family groups or in mixed flocks. During early August the mixed flocks were composed almost entirely of the local nesting species, but as the month progressed an ever-increasing number of transients from the north were found associated with them.

The fall migration of warblers started with the first cold snap after about the 12th of the month. Previous to this date temperatures in the lower fifties had no noticeable effect on warblers, but the first cool night afterwards was certain to bring at least scattered individuals of a few species, and occasionally fairly large numbers were found. In the absence of cool nights during the latter half of the month only a few scattered transients arrived. August, 1947, for instance, was the warmest recorded since 1900, and temperatures were above normal every single night after the sixth. Only four transients were recorded during August that year. These were: a single Canada Warbler on the 12th, a lone Yellow Warbler on the 14th, a Bobolink on the 20th, and a Magnolia Warbler on the 29th.

Although no spectacular flight of Nighthawks occurred over the Refuge, small flocks comprising up to 35 individuals were often seen during late August and early September, and occasionally large groups were observed.

The migration peaks for the Spotted Sandpiper and Solitary Sandpiper occurred during August. Most of the other transients that were seen passed through the Refuge in two general waves. The migration period for each of these varied considerably from year to year, depending on weather conditions. The characteristic species are listed as follows:

(August 15-September 20)

Whip-poor-will
Nighthawk
Ruby-throated Hummingbird
Least Flycatcher
Loggerhead Shrike
Black and White Warbler
Worm-eating Warbler
Golden-winged Warbler
Blue-winged Warbler
Yellow Warbler
Chestnut-sided Warbler
Prairie Warbler
Louisiana Water-thrush
Yellow-breasted Chat
Hooded Warbler
Wilson's Warbler
Canada Warbler
Bobolink
Baltimore Oriole

(August 25-September 30)

Sora	Yellow-throated Vireo
Yellow-billed Cuckoo	Blackburnian Warbler
Black-billed Cuckoo	Bay-breasted Warbler
House Wren	Northern Water-thrush
Wood Thrush	American Redstart
Veery	Scarlet Tanager
White-eyed Vireo	Indigo Bunting

By the end of August the majority of the individuals of several resident, insectivorous species had departed. These include the Eastern Kingbird, Crested Flycatcher, Acadian Flycatcher, Barn Swallow, and Kentucky Warbler. Most of the visiting southern herons had also returned to the south by this date, as had the majority of the transient swallows.

September.—Occasional 90° temperatures during the day as well as a few chilly nights could be expected in September. Heavy rains were comparatively frequent, 24-hour totals in excess of one inch being recorded in each of the past five years. Those reaching flood proportions were as follows: 2.65 inches on September 13-14, 1944; 3.76 inches on September 17-18, 1945; and 2.68 inches on September 23-24, 1946, preceded by 1.50 inches on the 21st.

September Climatic Data

Mean temperature: 68.2°.	to 84°.
Maximum monthly temperatures: 92° to 98°.	Mean minimum daily temperatures: 50° to 60°.
Minimum monthly temperatures: 31° to 43°.	Mean precipitation: 3.90 inches.
Mean maximum daily temperatures: 80°	Monthly precipitation extremes: 2:61 inches to 5.54 inches.

The typical autumn flora was at its peak during September. Most of the well-drained fields and clearings were dominated by the flowers of several species of goldenrod, Aster (*Aster pilosus*), and Sweet Everlasting (*Gnaphalium obtusifolium*), while many other species were common locally. Plants found in damp or marshy meadows were particularly colorful at this time of the year, with yellow, blue, purple, and white flowers blending together in harmonious array. The more common species found in such habitats were Joe-Pye Weed (*Eupatorium purpureum*), Boneset (*Eupatorium perfoliatum*), Flat-top Goldenrod (*Solidago graminifolia*), Swamp Aster (*Aster puniceus*), Ironweed (*Vernonia noveboracensis*), and beggarticks (*Bidens* spp.). Conspicuous woodland species now in flower included Wood Aster (*Aster divaricatus*), Woodland Goldenrod (*Solidago caesia*), White Turtlehead (*Chelone glabra*), and Cardinal Flower.

Several kinds of wild fruit ripened during September and became available for food. These include Blackgum, Flowering Dogwood (*Cornus florida*), Frost Grape (*Vitis vulpina*), Summer Grape (*Vitis aestivalis*), Spicebush (*Lindera benzoin*), Pawpaw (*Asimina triloba*), and Sumac (*Rhus copallina* and *R. glabra*).

The autumn coloration of the foliage on several species of woody plants gradually became more apparent. Many of the leaves on Tulip-trees had

started changing to a bright yellow, while those of several species including Wood-bine (*Parthenocissus quinquefolia*), and Shining Sumac (*Rhus copallina*) were changing to a brilliant red.

September was the most interesting month of the fall, ornithologically. The warbler flight was at its peak and it was during this month that the majority of nesting species made their departure, the first winter residents arrived and the greatest variety of transients passed through. Arrivals and departures of these birds were closely correlated with weather conditions. Cold nights with northwesterly winds, particularly when preceded by several days of warm weather or opposing winds, could be counted upon to bring great waves of migrants at any time in the month. Long stretches of unbroken warm weather, on the other hand, not only precluded the arrival of birds from the north, but delayed the departure of those which were already here.

Unseasonably warm weather prevailed in 1947, when the consistently above-average temperatures which commenced on August 7, continued unbroken until the 17th of September; and it was not until six days after this that the mercury dropped appreciably below 50°. Departures of many species were delayed two weeks, and scattered individuals remained to unprecedented dates. Strangely enough, the greatest effect showed up in October. A series of frosty mornings at the close of September was insufficient to drive all the belated migrants south, so an amazing variety of "September" birds was caught in another warm spell in October and retained to even later dates.

Two major migration waves ordinarily made their appearance during September. In the first of these, insectivorous species still predominated, while in the second the omnivorous or herbivorous species were more numerous. The characteristic species of each wave are listed as follows:

(September 5-October 10)

Broad-winged Hawk
Osprey
Chimney Swift
Red-headed Woodpecker
Eastern Wood Pewee
Catbird
Brown Thrasher
Olive-backed Thrush
Gray-cheeked Thrush
Red-eyed Vireo
Philadelphia Vireo
Tennessee Warbler
Nashville Warbler
Parula Warbler
Magnolia Warbler
Cape May Warbler
Black-throated Blue Warbler
Black-throated Green Warbler
Pine Warbler
Oven-bird
Yellow-throat
Rose-breasted Grosbeak

(September 20-October 30)

Wood Duck
Sharp-shinned Hawk
Cooper's Hawk
Red-tailed Hawk
Marsh Hawk
Pigeon Hawk
Sparrow Hawk
Greater Yellow-legs
Belted Kingfisher
Flicker
Yellow-bellied Sapsucker
Eastern Phoebe
Blue Jay
Red-breasted Nuthatch

Short-billed Marsh Wren
Eastern Bluebird
Blue-headed Vireo
Black-poll Warbler
Western Palm Warbler
Connecticut Warbler
Cowbird
Eastern Towhee
Savannah Sparrow
Vesper Sparrow
Chipping Sparrow
Lincoln's Sparrow
Swamp Sparrow

One of the most interesting features of the September migration was the southward flight of hawks, especially the mass movement of Broad-winged Hawks. The best flights in Maryland were found in the parallel mountain ridges, the nearest of which is 45 miles west of the Refuge; but other large-scale migrations have been noted along the coast. The only unusually large fall flight of Broad-winged Hawks over the Refuge was witnessed on the afternoon of September 22, 1944, when 1,032 hawks of this species, together with 34 other hawks were counted between 3:00 and 4:15 P.M. This flight took place on a light northwesterly wind, a rising barometer, moderate temperature (75°), and a sky half-covered with high cumulus clouds. The four days preceding the flight had been overcast, with considerable rain and drizzle, and easterly, southeasterly, or southwesterly winds. A heavy thunderstorm on the night preceding the flight was followed by clearing skies and a drop in temperature. A particular effort was made to locate another flight on the following day, since weather conditions remained nearly the same except for a 7° drop in temperature. One hundred and eighty-seven hawks were recorded, all but 20 being seen between 8:15 and 11:45 A.M. The third best September hawk flight was observed on the afternoon of September 21, 1945, when 156 birds were counted between 1:35 and 4:15 P.M. This was three days after the passage of a tropical storm; no rain had occurred in the meantime, but winds had been either southerly or light and variable during each of the intervening days. A cold front, with an accompanying shift to northwesterly winds, had passed over the area in the early morning of the date of the flight.

TABLE 5.—Summary of the three largest September hawk flights

Species	Sept. 22, 1944	Sept. 23, 1944	Sept. 21, 1945
Sharp-shinned Hawk	1	7	13
Cooper's Hawk	8	18	5
Red-tailed Hawk	10	1	3
Red-shouldered Hawk	6	4	2
Broad-winged Hawk	1032	148	111
Bald Eagle	0	1	0
Marsh Hawk	0	3	0
Osprey	0	1	2
Pigeon Hawk	1	0	0
Sparrow Hawk	5	2	8
Unidentified	3	2	12
Total	1056	187	156

October.—Clear skies and cool weather were associated with October, but more important ecologically were the killing frosts which usually occurred at some time during the month. In extreme cases these conditions occurred in the closing days of September (1947) or not until mid-November (1946). Heavy rains and floods were rare in October. The only October rain during the past five years which amounted to more than one inch occurred on October 26, 1947, when 3.46 inches fell.

October Climatic Data

Mean temperature: 55.5°.
Maximum monthly temperatures: 82° to 88°.
Minimum monthly temperatures: 24° to 32°.
Mean maximum daily temperatures: 68° to 75°.
Mean minimum daily temperatures: 40° to 47°.
Mean precipitation: 3.28 inches.
Monthly precipitation extremes: 1.07 inches to 5.25 inches.

The major changes in coloration of the autumn foliage took place during the first half of the month. Usually at this time the entire landscape was suffused in a blaze of color. During the last half of October most of the leaves gradually became withered or changed to a drab brown and soon after fell to the ground. By the end of the month the majority of the woody plants were largely bare. The foliage on most of the oaks, however, changed color during the latter half of October, while the leaves persisted on the trees for a considerable time afterward.

Many of the autumn flowers so prevalent in September continued blooming through part of October. To these species could be added the Closed Gentian (*Gentiana clausa*), while several species of morning glories (*Ipomoea* spp.) became much more conspicuous at this time.

A considerable variety of fruit, mast, and seed was available as food for birds and wildlife in general. The mast included the nuts or acorns of several species of hickory (*Carya* spp.), oak (*Quercus* spp.), Beech (*Fagus grandifolia*), Hazelnut (*Corylus americana*), and Chinquapin (*Castanea pumila*). Fleshy fruits now available included: Black Haw (*Viburnum prunifolium*), Arrow-wood (*Viburnum dentatum*), Blackgum, Flowering Dogwood, Persimmon (*Diospyros virginiana*), Pawpaw, Holly (*Ilex opaca*), Winterberry (*Ilex verticillata*), Poison Ivy (*Toxicodendron radicans*), Strawberry-bush (*Evonymus americanus*), Spicebush, Pokeberry, Summer Grape, Frost Grape, Japanese Honeysuckle (*Lonicera japonica*), and Shining Sumac. The available supply of seeds was produced by many different types of plants. In the fields, different species of grasses, and weed species such as Ragweed and Smartweed (*Polygonum pennsylvanicum*) produced most of the seeds that were used for food. In the forests and swamps, Sweetgum, Tulip-tree, two or three species of ash (*Fraxinus* spp.), Alder (*Alnus serrulata*), and False Nettle were some of the more important species which usually produced ample supplies of seed.

Drastic changes in bird populations occurred during October. The first heavy frost generally caused the departure of most of the insectivorous

species which were so predominant in September. The sparrow migration reached its peak in October, the best flights appearing, as might be expected, after cold nights with northwesterly winds. Under these conditions from 1,000 to 2,500 individuals were counted in the morning census trips. Blackbird flights were less predictable and varied tremendously in volume and dates of occurrence from year to year. The first big flight of many of the wintering species, such as the Yellow-bellied Sapsucker, Brown Creeper, Winter Wren, Hermit Thrush, and Golden-crowned Kinglet, occurred after the first or second cold spell in October, although a few individuals of these species frequently arrived during the closing days of September.

Ordinarily only one new major wave of migrants could be distinguished in October. The characteristic species are listed as follows:

(October 5-November 20)

Canada Goose	Ruby-crowned Kinglet
Mallard	American Pipit
Black Duck	Myrtle Warbler
Baldpate	Yellow Palm Warbler
Pintail	Eastern Meadowlark
Ring-necked Duck	Red-wing
Coot	Rusty Blackbird
Killdeer	Grackle (Purple and Bronzed)
Horned Lark	Purple Finch
White-breasted Nuthatch	Slate-colored Junco
Brown Creeper	Field Sparrow
Winter Wren	White-crowned Sparrow
Robin	White-throated Sparrow
Hermit Thrush	Fox Sparrow
Golden-crowned Kinglet	Song Sparrow

The best flights of Canada Geese were recorded on cool days with northwesterly winds, often immediately preceded by one or more days of rain or southerly winds. Geese seldom alighted on the Refuge ponds, but in one case a flock of 43 was seen on Lake Redington two hours before the arrival of a cold front and heavy line squall. Ducks, particularly diving species, were most frequently found on the ponds during or immediately following rainy, foggy, or heavily overcast weather.

October hawk flights were not so spectacular as those of September. The best flights, noted casually, were on days with light northwesterly winds, preceded by several days of poor flying conditions. The latest flight occurred on October 31, 1943, when eight Red-tailed Hawks, eight Red-shouldered Hawks, one Marsh Hawk, and one Duck Hawk were seen in a single loose flock at 4:45 P.M.; five other Red-tails passed by in the next ten minutes.

October, 1947, was so exceptional that it deserves special mention. That year the warm weather of August and September was broken by a cold spell which extended from September 23 to October 4. From the latter date

on, temperatures remained well above normal for the rest of the month without a single exception. Twenty-three species seen during October, 1947, were recorded on later dates than ever before. Of these the Eastern Kingbird, Black-billed Cuckoo, Canada Warbler, Veery, Blue-winged Warbler, and Connecticut Warbler were seen from 16 to 25 days after the latest previous record; and the Blue Grosbeak, Red-eyed Vireo, Tennessee Warbler, Black-poll Warbler, Parula Warbler, Chestnut-sided Warbler, Oven-bird, Northern Water-thrush, and Nashville Warbler were found from 6 to 15 days later than in any previous year.

November.—The first snows, generally only flurries, were expected in November. In some years, however, as in 1946 and 1947, not even flurries were recorded. Precipitation was generally light, although one to 2.06-inch rainstorms occurred 6 times in 5 years, causing minor floods along the Patuxent River.

November Climatic Data

Mean temperature: 45.5°.
Maximum monthly temperatures: 72° to 80°.
Minimum monthly temperatures: 15° to 19°.
Mean maximum daily temperatures: 57° to 63°.
Mean minimum daily temperatures: 30° to 36°.
Mean precipitation: 2.97 inches.
Monthly precipitation extremes: 1.24 inches to 5.73 inches.

The winter aspect of the vegetation gradually became more apparent during the first half of November as most of the few remaining leaves on the trees and shrubs continued to fall. By the middle of the month, this bare, leafless appearance was quite general, although occasional trees, especially some of the oaks, retained their brown withered leaves throughout the winter. The same plant foods were present that were found during October, although many of the fleshy fruits were found in greatly reduced quantities by this time.

By early November most of the cold-blooded vertebrates, including snakes, lizards, and turtles, had gone into hibernation, and the insect population had become greatly reduced.

The last major wave of fall migrants made its appearance in November. The characteristic species are listed as follows:

(November 1-December 5)

Horned Grebe
Whistling Swan
American Golden-eye
Buffle-head
Ruddy Duck
Hooded Merganser
American Merganser
Woodcock
Horned Owl
American Crow
Tree Sparrow

November was a blackbird month. Flights of Grackles, Red-wings, Rusty Blackbirds, and Cowbirds varied tremendously from year to year both as to

numbers of individuals and dates of occurrence. Small numbers were seen on almost any fair day during the month, but the large flights were completely unpredictable. They usually came on cold days although many a fine cold day went by without any major movement taking place.

The Tree Sparrow, last regular winter resident to arrive from the north, put in its appearance on about the 7th of November, almost always on a frosty morning. After the arrival of the first bird, others were seen in slowly increasing numbers. Since the Refuge is so close to the southern limit of the Tree Sparrow's winter range, there was no migration "peak," the species gradually becoming more common until wintering numbers were reached.

Rainy or heavily overcast weather in November was almost sure to bring at least a few diving ducks to the Refuge ponds. Some of the largest flights occurred during northeast rainstorms, but others have occurred on northwesterly winds provided skies were heavily overcast and rain or snow was falling in the vicinity. With the approach of fair weather, these birds usually left in a few hours. Some of the more interesting flights of diving ducks, and other water birds, are listed in the following table (when the flight continued for two days, the highest one-day total is given for each species):

TABLE 6.—November waterfowl flights

Species	Nov. 2–3 1946	Nov. 4 1945	Nov. 11–12 1945	Nov. 14 1943	Nov. 16 1947	Nov. 26 1947
Horned Grebe	—	—	—	—	5	—
Black Duck	1	—	—	6	6	1
Mallard	—	—	—	—	4	—
Gadwall	—	—	—	8	—	—
Baldpate	2	5	—	—	2	—
Pintail	—	4	—	—	—	—
Ring-necked Duck	7	3	—	—	—	2
Lesser Scaup Duck	1	—	—	—	—	—
American Golden-eye	—	—	18	12	3	2
Buffle-head	2	22	7	—	2	4
Old-squaw	—	—	3	—	—	—
Ruddy Duck	34	1	15	—	—	4
Hooded Merganser	—	—	—	30	—	31
American Merganser	—	—	18	—	—	—
Red-breasted Merganser	—	6	—	—	—	1
	—	—	—	—	—	—
Total	47	41	61	56	22	45

(Birds known to have been present before each flight were excluded from the table)

December.—December was often the driest month of the year and in some seasons the coldest. Precipitation in excess of one inch in a day occurred on only two occasions during the past five years, and in both

cases it came in the form of rain. On the average, 5 or 6 inches of snow fell during the month, extremes ranging from a trace to 15.2 inches.

December Climatic Data

Mean temperature: 35.6°.
Maximum monthly temperatures: 57° to 73°.
Minimum monthly temperatures: –4° to 11°.
Mean maximum daily temperatures: 39° to 53°.
Mean minimum daily temperatures: 20° to 27°.
Mean precipitation: 2.76 inches.
Monthly precipitation extremes: 1.53 inches to 6.00 inches.

The description of vegetation for January (see page 283) applies equally well to December. Important winter plant foods present at this time, other than the seeds of many weeds and grasses, included the following: mast from Beech and oaks; fruits and seeds from Poison Ivy, Grape, Sweetgum, Tulip-tree, Persimmon, Winterberries, Shining Sumac, and Japanese Honeysuckle.

The most noticeable effects of December weather on the departure of late fall migrants were prolonged cold periods which caused the ponds to freeze over, and heavy snow falls which drove the last transient blackbirds and sparrows southward. Ducks were seen regularly as long as the ponds were open, but freezing of the shallow water around the edges drove away the surface-feeding species, and as soon as the greater part of the surface was covered with ice, diving species departed too. Thaws later in the month usually did not result in a return of waterfowl to the Refuge, except for the American Merganser which occasionally appeared.

The important role which weather plays in bird migration is portrayed just as vividly in this cold month as during the height of the migration periods. Just as warm spells in spring bring about early arrivals at any time from late January to May, and cold weather in any month of the fall causes the premature departure of certain species, a warm, open autumn through the northeast may delay the grackle flight through this region. Such a phenomenon took place in 1944. No large flights of grackles were noted in October that year (maximum in one day, 450) and on only three days in November were more than 100 individuals recorded. However, the December flight was spectacular; of 143,800 grackles recorded during the fall of 1944, nearly 98 percent were counted during this month, and approximately five-sixths of the entire fall flight took place on December 19-21.

Comparison with Population Changes in Other Areas

The seasonal aspection on the Refuge was apparently fairly typical of eastern and east-central United States, at least as far as changes in bird populations and migratory movements were concerned. Major seasonal changes in population at Trelease Woods, near Urbana, Illinois (Twomey, 1945); in a climax beech-maple community 16 miles northeast of Cleveland, Ohio (Williams, 1936); in the Buckeye Lake region, Ohio (Trautman,

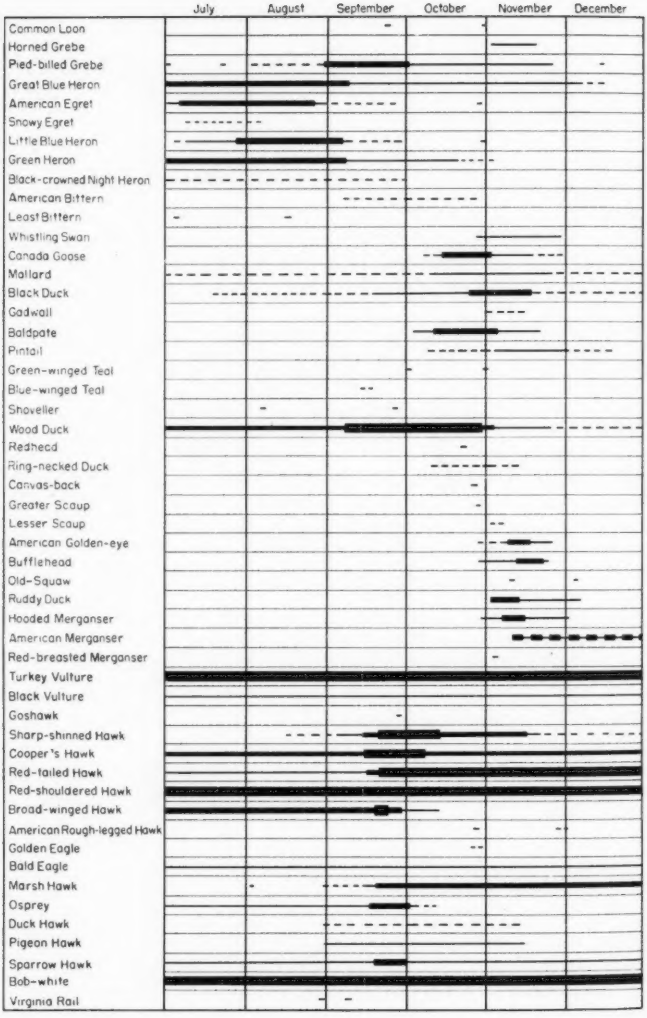

Fig. 8A.—Chart showing seasonal distribution and relative abundance of species recorded on the Refuge during the period July to December, inclusive. The occurrence of a species is shown by lines extending through the periods of residence. A solid line indicates regular occurrence, while a broken line indicates irregular occurrence. The four widths of line correspond to the terms: rare, uncommon, common, and abundant. Extreme dates for a few species recorded in 1948 and 1949 were made after this chart was completed and are not included.

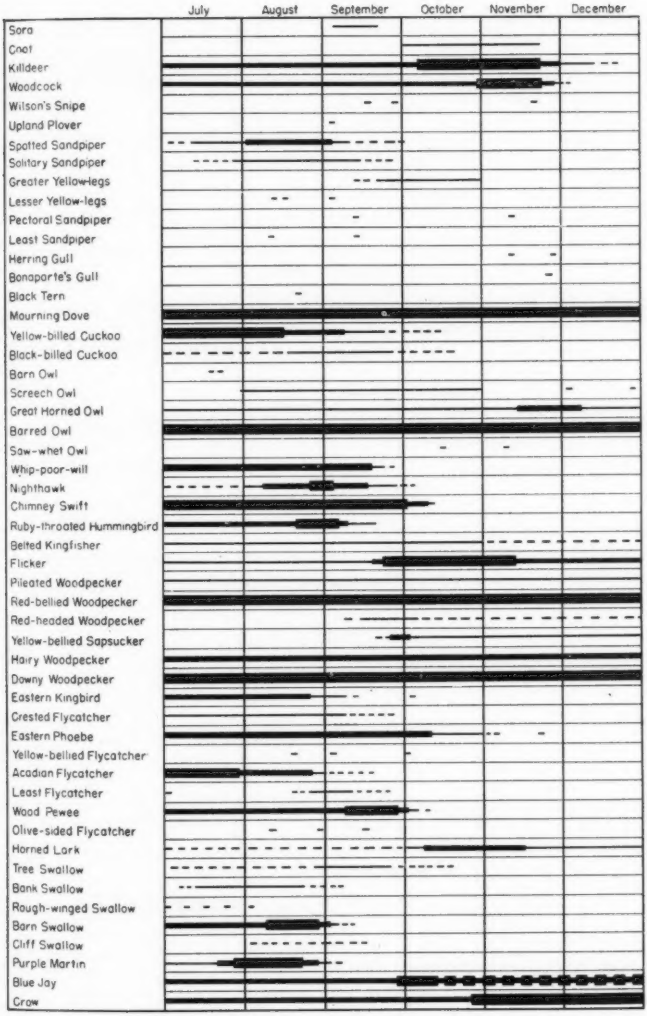

Fig. 8B.—See fig. 8A for description

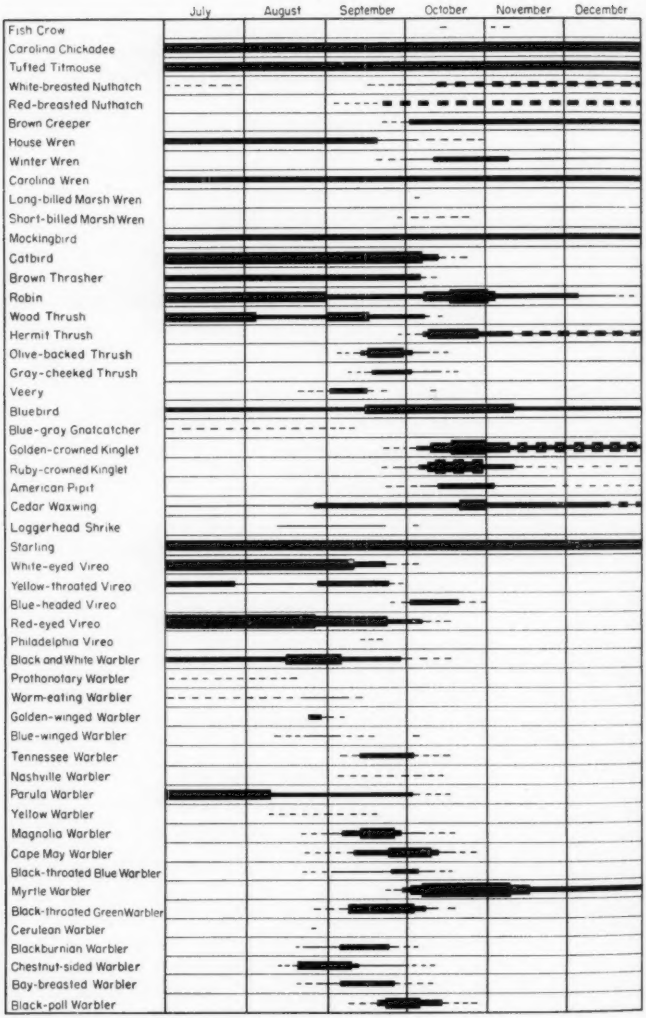

Fig. 8C.—See fig. 8A for description

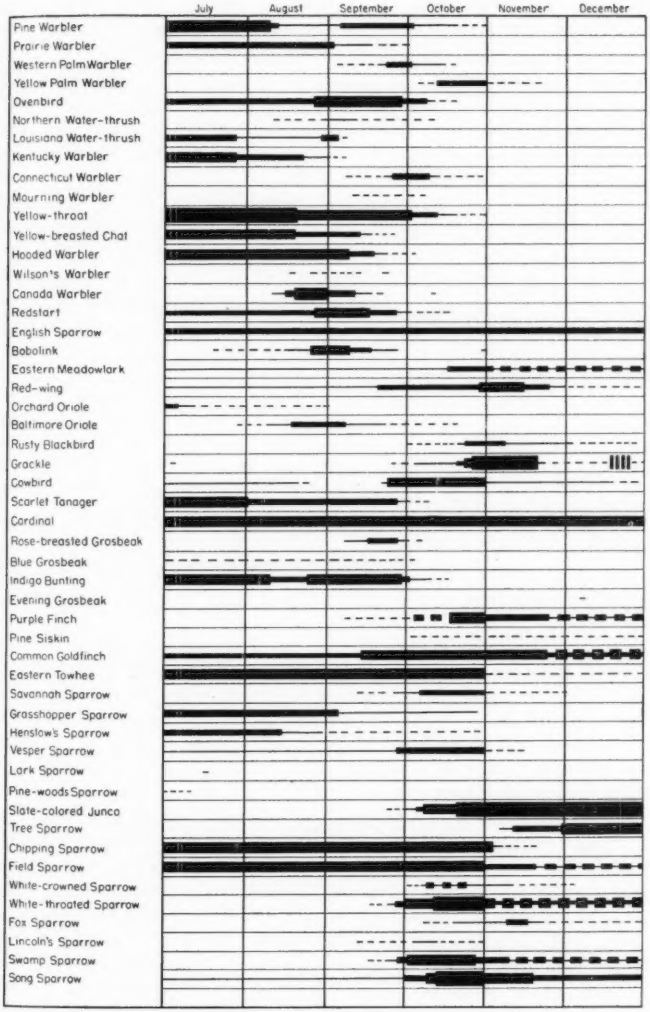

Fig. 8D.—See fig. 8A for description

1940); at the University of Wisconsin Arboretum (Anderson, *et al.*, 1942); and in the New York City region (Cruickshank, 1942), all show a marked similarity to corresponding changes on the Refuge.

Differences in climatic conditions are reflected in the phenological changes, which occur slightly earlier in spring and later in fall in the warmer, more southern areas. Also, the frequency of occurrence of species of southern affinities or species of northern affinities may be correlated directly with differences in latitude. Transient species in the Ohio areas were considerably more important numerically than on the Refuge, while winter residents were less important. The total population curve, as determined from studies in the beech-maple community in Ohio differed from the Refuge curve, principally in that the spring migration peak was nearly as high as the fall peak. It is probable that this difference may be accounted for by the fact that the Ohio study was made entirely in a single forest habitat, while the Refuge studies covered nearly all of the representative habitats in the area. Many forest species occur more commonly in open habitats during the fall migration than at any other time, so that seasonal population studies that cover mixed forest and field habitats would show a comparatively greater fall population than would studies which are restricted to forest habitats. A seasonal population study which was made in a 10-acre woods near Urbana, Illinois (Dirks-Edmunds, 1947) showed a much greater population peak in spring than in fall. However, the small size of the single habitat studied and the fact that almost 90 percent of the spring population peak was composed of one species (the Robin) would indicate that the results are perhaps not representative of the region as a whole.

At Cape May, New Jersey (Stone, 1937), the species numerical curve was found to differ from most of the other areas that have been intensively studied in the east, in that the number of species present at one time during the fall was much higher than the number present in the spring. This condition may be due to difference in habits of the many species of shorebirds and water birds that are so characteristic of the coastal areas and which are especially numerous at Cape May.

The yearly variations in wintering populations at Buckeye Lake, Ohio (Trautman, 1940), were even greater than the considerable yearly variation which frequently occurs on the Refuge. Trautman describes the situation at Buckeye Lake as follows: "In those winters when conditions were most unfavorable there were present approximately half as many species and less than half the number of individuals that there were during the most favorable winters. This fluctuation in numbers of species and individuals was caused by the presence, absence, or degree of intensity of many factors, principal among which were the climatic conditions of the autumn preceding a winter, the mean and extreme temperatures during a winter, and the amount of water, ice, snow, food and cover." These factors are believed to be similarly operative on the Refuge, although supply of food

appeared to be much more important than any of the others for the greatest number of species. In Kalamazoo County, Michigan, Allen (1938) found that the flocks of song birds left a 500-acre farm area entirely during a food shortage in February, 1936. Kendeigh (1944) found a very great yearly variation in the wintering population of Trelease Woods (55 acres), Illinois. Censuses were taken on this area for 14 years, and the yearly totals varied from 36 birds to 212.

Seasonal changes in bird populations in the west are apparently quite different from those in the east. In central Oklahoma (Nice, 1927), a three-year population study was made in a woods along a half-mile stretch of creek bed. Here it was found that the population of individuals was highest either in winter or early spring, and lowest in mid-fall. However, the maximum number of species was found to occur in late spring, as it does on the Refuge. Grinnell (1914) in commenting on the birds of the Berkeley Campus, California, mentioned that the number of species seen at any one time was fairly constant throughout the year. The number of transient species in this area was rather low compared to areas in the eastern United States.

Species Account

The seasonal distribution for each of the 229 species of birds that were recorded on the Refuge is described in the following pages. The species are arranged in taxonomic order according to the 4th Edition of the A.O.U. Check-list (1931). The common and scientific names of each species are given. This is followed by a brief statement on the seasonal status of the species concerned. If the species was migratory, and if numerous records of its occurrence were available, the more pertinent dates of its occurrence are then listed. These include earliest dates of arrival, median dates of arrival, periods of migration peaks, median dates of departure, and latest dates of departure of migrating individuals. The median dates of arrival (or departure) are so chosen that half of the yearly dates of arrival (or departure) fall before, and half after them. The use of median dates rather than means (commonly called averages) makes possible the inclusion of data for all years for which observations were available, without giving undue emphasis to unusual extreme dates. These are not to be compared with the "median" dates of Trautman (1940) which according to his definition are actually means. The numbers in parentheses immediately following the dates of median arrival or median departure, represent the number of years upon which the medians are based. Migration peaks were arbitrarily chosen as the periods during which from two-thirds to three-fourths of the total number of migrating individuals were recorded.

Seasonal population indices are used to show trends in population changes for most of the more common species. They represent the average number of individuals recorded per census trip for the periods indicated during the two-year, seasonal population study. A plus (+) sign, when used, indicates

an average of less than one-half. The dates of occurrence are represented by fractions (month/day).

In many cases the seasonal population indices are followed by a short discussion of seasonal changes in population, with reference to population figures for the breeding and winter seasons, highest one-day count during migration, size of flocks, unusual records of occurrence, and correlation of environmental factors with seasonal population changes. The highest one-day count refers to the highest number seen in one day by one observer, or one party of observers, on general bird observation trips. By spending the entire day in the optimum habitat of a given species, much higher counts could have been obtained in many cases. Records of special interest obtained between August 1, 1949 and October 1, 1950 are inserted in brackets, since these were made after the original manuscript had been completed.

An asterisk (*) preceding the scientific name of a bird indicates that a specimen has been taken on the Refuge. Reference to subspecies has been omitted purposely, since most of the data used in this paper are based on sight records. An exception to this is made in the case of the races of the Palm Warbler and Grackle, which are readily identified in the field without collecting. The scientific names of the species are based on the 1931 A.O.U. Check-list, and the more recent supplements which appeared in the July issues of *The Auk* from 1944 through 1949. All specimens referred to are either in the Patuxent Research Refuge collection of the U. S. Fish and Wildlife Service, or in the personal collection of Dr. I. N. Gabrielson, which is also at the Refuge.

The following terms used to indicate abundance or period of residence in the statements on seasonal status, are nearly the same as those used by Trautman (1940):[1]

Abundant: indicates that a species, considering its habits, was found in very large numbers.

Common: means that a species, considering its habits, was found in fairly large numbers.

Uncommon: refers to a species, that, considering its habits, occurred in rather small numbers.

Rare: applies to a species that was recorded quite regularly but in very small numbers.

Very Rare: used for a species within its normal range that was recorded irregularly and in very small numbers.

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1 During the progress of this study it was of considerable interest to notice that the relation between our numerical counts and the six categories of abundance, coincided in almost every case with Milton Trautman's table (Trautman, 1940: 152-153) showing the relative abundance of birds at Buckeye Lake, Ohio. Notable excepticns occurred in the case of some of the ducks and shorebirds, where there is a marked difference in the amount of suitable habitat in the two areas. Our only change in his categories was the application of the term "abundant" to his two highest divisions, "very common" and "abundant." Since the numerical definitions of Trautman apply so well to the Patuxent area, it is believed they might apply equally well to other sections of eastern United States, and possibly serve as a preliminary standard which might well be used by other ornithologists in comparing the abundance of various species in different regions.

Casual: refers to a species slightly beyond its usual range that was recorded once or twice during the period of the study.

Permanent Resident: indicates that a species occurs throughout the year in fairly constant numbers.

Summer Resident: means a species that nests on the Refuge (and occurs during the summer).

Winter Resident: applies to a species that remains on the Refuge throughout the winter months.

Transient: designates a species in migration through the Refuge, or a newly-arrived or departing individual.

Visitor: denotes a vagrant species which occurs on the Refuge rather irregularly and for indefinite periods.

Common Loon, *Gavia immer.*—Uncommon spring transient; very rare fall transient. In spring, earliest arrival, April 4, 1941; median arrival, April 13 (6); migration peak, April 25 to April 29; median departure, May 10 (5); latest departure, May 15, 1945. In fall, earliest arrival, September 23, 1943; latest departure, October 31, 1943. The numbers of Common Loons observed at one time during the spring migration are as follows: 14 single birds, 7 pairs, 4 flocks of 3, 2 flocks of 5, 3 flocks of 6, 3 flocks of 7, 2 flocks of 8, 1 flock of 12, and 1 flock of 15. Large numbers were seen on 3 days only: 27 on April 29, 1943; 47 on April 25, 1944; and 27 on April 29, 1945. Two records made during the fall were of single birds.

Holboell's Grebe, *Colymbus grisegena.*—Very rare spring transient. One Holboell's Grebe in breeding plumage was observed repeatedly on March 9, and another on March 24, 1948, during the biggest flight of this species ever recorded through the interior of Maryland, Virginia, and West Virginia.

*Horned Grebe, *Colymbus auritus.*—Rare spring and fall transient. In spring, earliest arrival, March 26, 1949 [March 11, 1950]; latest departure, April 23, 1944 [May 6, 1950]. In fall, earliest arrival, November 2, 1943 [October 26, 1949]; latest departure, December 4, 1948. Numbers of Horned Grebes observed at one time in spring were: 8 single birds, 1 pair, 1 flock of 5, and 1 flock of 8 (April 22, 1944). Fall observations were: 1 on November 2, 1943; and 1, 5, and 1 on November 15, 16, and 18, 1947, during and following an easterly storm. This same storm also brought small numbers of Horned Grebes to 2 ponds in the nearby towns of Beltsville and Greenbelt.

*Pied-billed Grebe, *Podilymbus podiceps.*—Uncommon spring and fall transient; rare summer visitor. In spring, earliest arrival, February 14, 1949; median arrival, March 4 (5); migration peak, March 22 to April 21; median departure, April 23 (3); latest departure, April 26, 1944. In fall, earliest arrival, July 21, 1944; median arrival, August 30 (4); migration peak, August 27 to October 1; median departure, November 14 (6); latest departure, December 15, 1946. Numbers of Pied-billed Grebes recorded in spring and fall ranged from 1 to 5 individuals per day. Single birds were recorded in late spring and summer on May 27, 1948, June 4, 1948, June 19, 1947, and July 1 to 3, 1948 [One pair remained on Refuge during summer of 1950.].

Great Blue Heron, *Ardea herodias.*—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, March 5, 1946; median arrival, March 15 (6); migration peak, March 22 to April 21. In fall, median departure, December 7 (4); latest departure, December 15, 1944 [December 19, 1949]. The Refuge population remained fairly constant from late March to early September, when as many as 6 individuals could often be found. Before and after this period, 1 or 2 birds were usually all that were seen in a day. Flocks of 3 to 6 individuals were sometimes recorded, particularly during migration. During the period of this investigation Great Blue Herons did not nest on the Refuge until 1947, when 1 occupied nest was found. In 1948 2 pairs nested at this same location.

American Egret, *Casmerodias albus.*—Uncommon summer visitor; very rare spring and fall visitor. Earliest post-breeding arrival, June 12, 1945; median post-breeding

arrival, July 2 (5); period of greatest abundance, July 6 to August 26; median departure, September 4 (6); latest departure, October 29, 1945. Two unusual records of seasonal occurrence were of a single bird observed repeatedly from May 15 to May 22, 1945 [One on June 1, 1950.], and of another seen on October 28 and 29, 1945. American Egrets were generally observed as singles or pairs, or in groups of from 3 to 5 individuals. Not over 6 were observed at one time except for a flock of 33 on July 8, 1946.

*Snowy Egret, *Leucophoyx thula.*—Rare summer visitor; very rare spring visitor. One adult female in breeding plumage was collected on May 16, 1945. A total of 15 observations of this species were recorded from 1946 to 1949 between July 8 (1947) and August 24 (1948). Two birds were observed on July 21, 1948, and on August 24, 1948, while all the other records were of singles.

Little Blue Heron, *Florida caerulea.*—Common or uncommon summer visitor. Earliest arrival, June 24, 1949 [One on June 1, 1950.]; median arrival, July 6 (8); period of greatest abundance, July 27 to September 6; median departure, September 7 (5); latest departure, September 27, 1944. Single birds and flocks comprising up to 18 individuals were recorded somewhat irregularly, each year.

*Green Heron, *Butorides virescens.*—Uncommon or rare summer resident and spring and fall transient. In spring, earliest arrival, April 8, 1947; median arrival, April 20 (8). In fall, migration peak, August 2 to September 7; median departure, October 14 (5); latest departure, November 3, 1942. This species occurred in small numbers throughout the warmer months, from 1 to 5 pairs nesting on the Refuge each year. Green Herons were generally observed as singles or pairs.

Yellow-crowned Night Heron, *Nyctanassa violacea.*—Very rare spring visitor. One adult was observed on May 10, 1948 [One remained during period, April 28-May 12, 1950.].

Black-crowned Night Heron, *Nycticorax nycticorax.*—Rare spring transient and summer visitor; very rare fall transient. In spring, earliest arrival, March 25, 1945; median arrival, March 30 (3). In fall, latest departure, October 1, 1938. This species occurred on the Refuge irregularly and in small numbers. The most seen at one time was a flock of 6 on April 25, 1944. The nearest known nesting colony was about 12 miles away.

*American Bittern, *Botaurus lentiginosus.*—Rare spring transient; very rare fall transient and summer visitor. In spring, earliest arrival, March 16, 1944; median arrival, March 25 (6); median departure, May 7 (6); latest departure, May 9, 1942. In fall, earliest arrival, September 7, 1944; latest departure, October 26, 1946. American Bitterns occurred regularly as single birds during the spring migration. Two individuals seen on April 22, 1941, represented the largest number recorded on one day. Five single birds were recorded in fall. Single birds were also seen in summer on June 1, 11, and 25, 1943, and on July 19, 1948.

Least Bittern, *Ixobrychus exilis.*—Very rare spring transient and summer visitor. Single birds were recorded on the following dates: May 15, 1943; May 15, 1945; May 25, 1949; June 16 and 18, 1948; July 4, 1942; and August 17, 1941.

Whistling Swan, *Cygnus columbianus.*—Rare spring and fall transient. During the spring migration, the majority of the flocks, ranging from 23 to 125 individuals, were recorded between March 13 and March 30 (early extreme, February 14, 1947). Fall flocks, of from 3 to 14, were noted somewhat less commonly, and during the period October 28 to November 29 [Three flocks of from 25 to 45 individuals seen during period, October 29 to November 1, 1949.].

Canada Goose, *Branta canadensis.*—Uncommon spring and fall transient [Common in fall of 1949 and winter of 1949-50.]. In spring, earliest arrival, February 22, 1945; median arrival, March 12 (5); migration peak, March 15 to March 24; median departure, April 6 (5); latest departure, April 13, 1945. In fall, earliest arrival, October 6, 1948 [September 28, 1950]; median arrival, October 11 (7); migration peak, October 14 to November 2; median departure, November 23 (4); latest departure, November 29, 1948. In spring, flocks were found to comprise from 10 to 210 individuals, with an aver-

age of 63 (14 flocks). Fall flocks were somewhat smaller, ranging from 7 to 100 individuals and averaging 35 (17 flocks). Seventeen wild Canada Geese from the Blackwater National Wildlife Refuge, Cambridge, Maryland, were released on Cash Lake during the spring and summer of 1945 and 1946. These birds were all pinioned or wing-clipped before release. Four died within a year. One pair successfully raised 2 young (out of 5) in the spring and summer of 1946 and 3 young (out of 5) in 1947. Some of the geese left the area for varying periods but all except 4 eventually returned. Twenty geese were present during the winter of 1947-48, including a group of 6 that were probably wild birds attracted to the area by the others [From 110 to 150 remained on Refuge from October 26, 1949 through the winter of 1949-50.].

*Mallard, *Anas platyrhynchos*.—Uncommon fall transient; rare spring transient; very rare summer resident and winter visitor [Common in winter of 1949-50.]. In spring, earliest arrival, January 18, 1947; median arrival, February 25 (6); latest departure, May 5, 1945. In fall, earliest arrival, October 9, 1947; median departure, November 25 (5); latest departure, December 31, 1940. During migration, this species was usually observed as single birds or in groups of 2 to 4. Occasionally in fall, flocks ranged up to 22 individuals. On March 15, 1947, 12 were found on the Refuge, mostly in pairs, and on February 28, 1948, a loose flock of 22 was seen. During the summers of 1944, 1945, and 1946, at least one pair remained on the Refuge to nest, while in 1947 at least two pairs were present. A group of 3 was seen several times during the winter of 1947-48 [Approximately 150 remained on Refuge during winter of 1949-50.].

*Black Duck, *Anas rubripes*.—Uncommon spring and fall transient; very rare summer and winter visitor [Common in winter of 1949-50.]. In spring, earliest arrival, February 16, 1948; median arrival, February 26 (5); migration peak, February 26 to March 23; median departure, April 17 (6); latest departure, April 28, 1946. In fall, earliest arrival, August 31, 1944 [August 24, 1949]; median arrival, September 14 (6); migration peak, October 25 to November 18; median departure, November 18 (8); latest departure, December 17, 1939. In spring, Black Ducks were recorded as singles or in groups of 9 or less. In fall, flocks comprising up to 24 individuals were occasionally seen, occurrences becoming more frequent in 1947 when there was an abundance of food in Lake Redington. Four birds seen on January 4, 1941, represented the only mid-winter record [Approximately 40 remained on Refuge during winter of 1949-50.]; and the only summer records were of 2 seen on 3 occasions during the period July 18 to August 3, 1948.

Gadwall, *Anas strepera*.—Very rare spring and fall transient and summer visitor. The Gadwall was recorded as follows: November 1, 1946 (1); November 11, 1938 (1); November 14, 1943 (flock of 8); April 17, 1948 (2); July 13, 1949 (1); and July 24, 1949 (1).

Pintail, *Anas acuta*.— Rare spring and fall transient; very rare winter visitor. In spring, earliest arrival, February 17, 1949; latest departure, March 26, 1949. In fall, earliest arrival, August 26, 1948; latest departure, December 17, 1939. During migration Pintails occurred as singles, pairs, or in small flocks comprising up to 17 individuals. A flock of 23 observed on January 9, 1949, represents the only winter record [Four remained on Refuge during winter of 1949-50.].

*Green-winged Teal, *Anas carolinensis*.—Very rare spring and fall transient [and winter resident]. This species was recorded as follows: February 19, 1949 (1); March 3, 1944 (pair); March 9, 1948 (1); March 10, 1946 (1); March 28, 1949 (2); April 14, 1946 (1); [April 29, 1950 (3)]; October 1, 1938 (1); and November 1, 1946 (2) [Two remained on Refuge during the winter of 1949-50.].

Blue-winged Teal, *Anas discors*.—Rare spring transient; very rare fall transient. In spring a few scattered records of from 1 to 4 birds were made each year between March 15 (1947) and May 23 (1949). In fall scattered observations were recorded from August 31 (1948) to September 16 (1947).

*Baldpate, *Mareca americana*.—Uncommon spring and fall transient. In spring, earliest arrival, February 13, 1949; median departure, April 19 (6); latest departure,

May 7, 1948. In fall, earliest arrival, October 3, 1943 [September 7, 1949]; latest departure, December 5, 1947. Baldpates occurred singly, in pairs, or in small flocks numbering up to 20 individuals.

Shoveller, *Spatula clypeata*.—Very rare spring and fall transient. Single birds were observed on August 6, 1944 (an extremely early record), September 26, 1943, October 6, 1948, and March 28, 1948.

*Wood Duck, *Aix sponsa*.—Common spring and fall transient; uncommon summer resident; very rare winter resident. In spring, earliest arrival, February 18, 1946; median arrival, February 25 (5); migration peak, February 27 to March 25. In fall, migration peak, September 9 to October 29; median departure, November 14 (6); latest departure, November 25, 1945. During the spring migration peak, Wood Ducks occurred commonly in pairs and occasionally in small flocks of from 3 to 10 individuals. In fall, this species tended to congregate in larger flocks, groups of 5 to 20 individuals being not unusual; occasionally as many as 100 were seen together. When congregating on their roosting areas in late summer and fall, even larger aggregations occurred. In 1944, Wood Ducks were first observed coming to their roosting ground on August 12, when 81 birds were counted. This number gradually increased until October 29, when 184 were recorded. After this the numbers steadily declined until the end of November, by which time the area was entirely deserted. Most ducks arrived at the roosting grounds in small flocks comprising less than 10 individuals. From 4 to 8 pairs remained on the Refuge to nest each year. Between 6 and 9 Wood Ducks remained on the Refuge during the winters of 1940-41 and 1941-42. However, they were apparently absent at this season during the other years of this study.

*Redhead, *Aythya americana*.—Very rare spring and fall transient and winter visitor [Common transient in spring of 1950.]. The only records of this species are the following: October 16-22, 1948 (1); October 21, 1944 (1); January 3, 1947 (1); and March 16, 1947 (2) [Six records of from 1 to 11 birds during period of October 25, 1949 to February 26, 1950; regular occurrence from March 17, 1950 to March 28, 1950, several dozen being present on latter date.].

*Ring-necked Duck, *Aythya collaris*.—Uncommon spring transient; rare fall transient. In spring, earliest arrival, February 27, 1946 [February 5, 1950]; median arrival, March 2 (6); migation peak, March 13 to April 4; median departure, April 6 (5); latest departure, April 26, 1940 [May 6, 1950]. In fall, earliest arrival, October 11, 1945; median arrival, November 1 (4); migration peak, October 31 to November 4; latest departure, November 28, 1948. Ring-necked Ducks were generally observed in groups of 8 birds or fewer. They were occasionally found in larger flocks in spring; the 2 largest, comprising 43 and 41 individuals, were seen on April 4, 1947, and April 2, 1940, respectively [Flock of 40 on March 20, 1950.].

*Canvas-back, *Aythya valisineria*.—Very rare spring and fall transient. The only Canvas-backs recorded on the Refuge were a male seen on March 30, 1946, a male on May 15-16, 1949 and May 28, 1948, and a female collected on October 26, 1945 [One to two birds remained during period March 11 to March 28, 1950; two on November 2, 1949.].

Greater Scaup Duck, *Aythya marila*.—Very rare spring and fall transient. This species was recorded as follows: 3 males and 1 female on March 1, 1945; 1 male on March 16, 1944; and 1 immature male on October 28, 1944. These sight identifications were all made at close range and were based on the following field characters: white stripe of wing extending nearly to tip, as viewed when flying; chunky, squarish-shaped heads; and green iridescence on head.

*Lesser Scaup Duck, *Aythya affinis*.—Rare spring transient; very rare fall transient. In spring, single birds or small groups containing up to 11 birds (April 22, 1944) were occasionally seen between March 20 (1940) and May 5 (1946). The only fall records were made in 1946, when a male was recorded November 2 to 6, and a female on November 2.

*American Golden-eye, *Bucephala clangula*.—Uncommon fall transient; rare spring

transient. In spring, earliest arrival, March 14, 1949; latest departure, April 22, 1944. In fall, earliest arrival, October 28, 1944; latest departure, December 19, 1948. In fall this species was usually found in small flocks; the largest containing 18 individuals, was recorded on November 11, 1945. In the spring only single birds or pairs were noted.

*Buffle-head, *Bucephala albeola*.—Uncommon fall transient; rare spring transient; very rare winter visitor. In spring, earliest arrival, March 16, 1947 [February 25, 1950]; latest departure, May 28, 1949. In fall, earliest arrival, October 28, 1944; median arrival, November 3 (6); median departure, November 24 (4); latest departure, December 20, 1948. In fall, Buffle-heads were generally found in small flocks. The largest, containing 22 individuals, was seen on November 4, 1945. In spring, not over 3 birds were recorded at one time [Seven on February 25, 1950]. Three observed repeatedly during the period January 3-6, 1947, represent the only winter record.

*Old-squaw, *Clangula hyemalis*.—Very rare spring and fall transient. The only observations of Old-squaws were as follows: March 26, 1949 (1) [One collected on March 31, 1950.]; April 15, 1945 (1); November 11, 1945 (3); December 5, 1945 (2); and December 19, 1948 (1).

Ruddy Duck, *Oxyura jamaicensis*.—Uncommon fall transient; rare spring transient; very rare winter visitor. In spring, earliest arrival, February 27, 1948; latest departure, May 31, 1948. In fall, earliest arrival, October 6, 1948 [September 28, 1950]; median arrival, November 3 (4); latest departure, December 6, 1945. The number recorded in one day ranged from 1 to 34 in fall, and from 1 to 5 in spring. The two largest flocks containing 21 and 13 individuals were both seen on November 3, 1946. One bird observed on January 27, 1949, represents the only winter record.

*Hooded Merganser, *Lophodytes cucullatus*.—Uncommon spring and fall transient; very rare winter visitor. In spring, earliest arrival, February 20, 1949; migration peak, March 11 to April 17; latest departure, May 27, 1949. In fall, earliest arrival, September 20, 1948; migration peak, November 7 to November 14; latest departure, December 5, 1947. Hooded Mergansers were generally recorded as singles, pairs or in small flocks comprising up to 8 individuals. Larger flocks containing 30 and 31 birds were seen on November 15, 1943 and November 26, 1947, respectively. Three observed on February 5, 1948, and 1 on January 9, 1949 [three on January 26, 1950], represent the only winter records.

American Merganser, *Mergus merganser*.—Uncommon spring and fall transient; irregular (uncommon or rare) winter visitor. In spring, earliest arrival, February 12, 1945; migration peak, March 15 to April 5; latest departure, May 18, 1944. In fall, earliest arrival, November 11, 1945; latest departure, December 24, 1940. Usually not over 8 individuals were observed at one time although occasional flocks comprising up to 18 were recorded. This species occurred in winter only when the lakes were partially free of ice. During the winter of 1948-49, American Mergansers were much more common than usual, from 35 to 45 individuals being recorded regularly, while on February 19, over 75 were noted.

*Red-breasted Merganser, *Mergus serrator*.—Very rare spring and fall transient and winter visitor. This species was recorded as follows: November 4, 1945 (6); November 26, 1947 (1); January 3, 1947 (1); March 14, 1948 (2); March 23, 1949 (1); March 24, 1948 (2); April 16, 1944 (3); and April 22, 1944 (2).

*Turkey Vulture, *Cathartes aura*.—Common permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 1 (7/27-9/4); 4, 6 (9/5-10/4); 2, 3 (10/5-12/14); 1, 1 (12/15-3/4); 4, 6 (3/5-5/24); 1, 2 (5/25-7/26). Small groups comprising up to 7 individuals were commonly seen throughout the year. Occasionally, when food was found, larger aggregations of up to 50 individuals occurred. During migration, especially in fall, even larger flocks were sometimes seen. On November 27, 1943, a flock of 246 birds was observed flying south, obviously migrating. Another flock of 64 was seen flying south on November 23, 1945. [Flock of 198 migrating west was recorded on January 19, 1950.] The only large migrating flock in spring contained 52 individuals and was seen on March 15, 1947. The average number of adult

Turkey Vultures present during the nesting season (late spring and early summer) of 1943, was 14. On February 10, 1944, the average number present at one time was also 14, as determined from an all-day census. A similar winter census was taken on February 12, 1945, and the average number present at one time was again 14.

*Black Vulture, *Coragyps atratus*.—Rare permanent resident. Black Vultures occurred rarely and somewhat irregularly throughout the year. They were apparently slightly more numerous in early spring (February 3 to March 27) and in fall (September 23 to November 16) than at other times. Most records were of singles or small groups comprising up to 7 individuals. A flock of 19 was seen on November 16, 1944. The data from the winter census of 1944-45 indicated that the average density of the Black Vulture at that time was approximately 1 bird per 30 square miles. This would mean a ratio of 1 Black Vulture to about 95 Turkey Vultures. In the banding work 222 Turkey Vultures and 4 Black Vultures were trapped.

Goshawk, *Accipiter gentilis*.—Casual visitor. One immature was seen on September 28, 1944.

*Sharp-shinned Hawk, *Accipiter striatus*.—Common spring and fall transient; rare winter visitor. In spring, earliest arrival, February 8, 1943; median arrival, March 4 (6); migration peak, April 7 to April 29; median departure, May 7 (5); latest departure, May 14, 1946. In fall, earliest arrival, August 16, 1943; median arrival, September 5 (6); migration peak, September 21 to October 12; median departure, November 16 (6); latest departure, December 28, 1941. Most records were of singles or twos. The highest daily count of 105 was made on April 26, 1946. The second highest count in spring was 13, on April 16, 1944. The highest fall count was 13 on September 21, 1945.

*Cooper's Hawk, *Accipiter cooperii*.—Common fall transient; uncommon winter resident, spring transient, and summer resident. In spring, earliest arrival, February 24, 1949; migration peak, April 7 to April 26; latest departure, April 26, 1945. In fall, earliest arrival, September 13, 1943; median arrival, September 18 (4); migration peak, September 15 to October 8; latest departure, November 23, 1944. Most records of this species were of singles or pairs. The highest number recorded in one day was 19 on April 26, 1945. Other high counts were 16 on September 23, 1944, and 8 on September 22, 1944. The Refuge nesting population in 1943 was 3 pairs. Average Refuge wintering populations during 1943-44 and 1944-45 were 1 and 4 individuals respectively.

*Red-tailed Hawk, *Buteo jamaicensis*.—Common fall transient and winter resident; uncommon spring transient; rare summer resident. In spring, migration peak, March 10 to March 28; latest departure, April 30, 1944. In fall, earliest arrival, September 21, 1945; median arrival, September 22 (3); migration peak, September 22 to October 21. Generally only 1 or 2 individuals were seen at one time. In fall, small groups comprising up to 8 individuals were occasionally seen. Highest daily counts in fall were 13 and 10 individuals seen on October 31, 1943, and September 22, 1944, respectively. Fifteen birds (12 in one hour) recorded on February 28, 1948, represent the highest in spring. An average of 1 pair remained on the Refuge to nest each year. Average wintering populations during 1943-44 and 1944-45 were 4 and 5 individuals respectively. Wintering populations usually showed a gradual decline toward the end of February.

*Red-shouldered Hawk, *Buteo lineatus*.—Common permanent resident. Migration peaks were from February 28 to April 7, and September 22 to October 31. This species was generally found as singles, or pairs, and rarely in small loose flocks during migration. Flocks of 8 and 7 individuals on October 31, 1943, and March 25, 1945, were the largest recorded. The breeding population on the Refuge during 1943 and 1947 was 6 and 5 pairs respectively. The average wintering populations during 1943-44 and 1944-45 were 10 and 6 individuals respectively.

Broad-winged Hawk, *Buteo platypterus*.—Common (occasionally abundant) fall transient; common spring transient; uncommon summer resident. In spring, earliest arrival, April 9, 1945; median arrival, April 13 (5); migration peak, April 16 to April 26; latest departure, April 26, 1945. In fall, migration peak, September 21 to September 23; median departure, September 29 (4); latest departure, October 13, 1946. During

migration, Broad-winged Hawks were sometimes seen in very large numbers. On September 22, 1944, a total of 1,047 was counted flying over in 75 minutes. Other large flights were 157 on September 23, 1944; 111 on September 21, 1945; and 171 on April 16, 1944. A small number of Broad-wings remained on the Refuge to nest each year. In 1943, the nesting population consisted of 4 pairs.

*American Rough-legged Hawk, *Buteo lagopus*.—Very rare fall, winter and spring visitor. This species was observed on the following dates: October 26, 1946; November 28, 1943; November 29, 1943; November 30, 1943 (collected); January 18, 1945; February 12, 1945; February 27, 1945; March 1, 1945; March 16, 1945; and April 6, 1945. Two birds were seen on April 6, 1945, and all of the other records were of singles.

Golden Eagle, *Aquila chrysaëtos*.—Very rare fall visitor. An immature bird was observed on October 26, 1945, and again on October 28, 1945.

Bald Eagle, *Haliaeetus leucocephalus*.—Uncommon spring and fall visitor; rare winter and summer visitor. Periods of greatest abundance were March 8 to April 27 and November 1 to November 22. Most records were of singles or pairs, with occasional observations of 3 and 4.

*Marsh Hawk, *Circus cyaneus*.—Uncommon spring and fall transient and winter resident; casual summer visitor. In spring, median departure, April 21 (5); latest departure, April 29, 1945 [May 30, 1950]. In fall, earliest arrival, August 26, 1948 [August 30, 1949]; median arrival, September 8 (5). Marsh Hawks were found somewhat irregularly throughout their period of occurrence. During the winter of 1944-45, however, they were much more common than usual and were observed practically every day. During this winter they were common through December, January, and up to February 8, after which a noticeable slump in numbers occurred. Marsh Hawks were nearly always recorded as singles, rarely in twos or threes. One bird observed on July 2, 1945, represents the only mid-summer record.

Osprey, *Pandion haliaetus*.—Common spring transient; uncommon fall transient; rare summer visitor. In spring, earliest arrival, March 15, 1947; median arrival, April 3 (10); migration peak, April 14 to April 26; median departure, May 9 (5); latest departure, May 17, 1947. In fall, earliest arrival, August 31, 1942; median arrival, September 13 (5); migration peak, September 18 to October 2; median departure, October 5 (6); latest departure, October 12, 1946. Most records of this species were of singles or pairs. A total of 43 migrating overhead in 6½ hours on April 26, 1945, was the largest number recorded in one day. Other records of flights include 6 seen on April 14, 1946, and 5 on April 21, 1940. Not more than 2 were recorded in one day during the fall. Singles or pairs were seen at irregular intervals during the summer.

Duck Hawk, *Falco peregrinus*.—Very rare spring and fall transient. Single individuals were recorded on the following dates: March 4, 1946; April 7, 1944; April 26, 1945; May 16, 1943; August 30, 1943; September 16, 1944; October 29, 1946; October 31, 1943; November 12, 1945; and November 13, 1943.

*Pigeon Hawk, *Falco columbarius*.—Rare spring and fall transient; casual winter visitor. In spring, earliest arrival, March 26, 1944; latest departure, May 11, 1945. In fall, earliest arrival, August 30, 1943; latest departure, November 14, 1943. One bird was seen on December 29, 1944.

*Sparrow Hawk, *Falco sparverius*.—Common spring transient; uncommon fall transient; rare winter resident; very rare summer resident. Migration peaks were from March 22 to April 16 and September 20 to September 30. Usually not over 3 were observed in one day during migration. Occasionally more were recorded, however, as is indicated by the following records: September 21, 1948 (8); September 21, 1945 (8); September 22, 1942 (5); September 22, 1944 (5); April 4, 1944 (7); April 16, 1944 (6); April 26, 1945 (7). During the spring of 1944, 21 migrating Sparrow Hawks were trapped from March 22 to April 22, while in 1947, 21 were trapped from March 16 to April 26. One pair remained in the summer to nest during 3 of the past 7 years. One or 2 birds were generally found in winter.

*Bob-white, *Colinus virginianus*.—Common permanent resident. Family groups of

from 5 to 15 individuals were seen during the summer and fall, the numbers gradually being reduced through predation, disease, etc. Most winter coveys were presumably made up of 2 or more family groups and by the end of January, contained an average of 11 (1945) to 16 (1944) birds (extremes 8 and 30). These coveys were further reduced by predation, etc., before pairing off took place in the spring. The adult population during the summer of 1943 was approximately 50 individuals. Mid-winter populations during 1943-44 and 1944-45 were 130 and 78 individuals, respectively.

Virginia Rail, *Rallus limicola.*—Very rare fall transient. Single birds were observed on August 29, 1938, and September 9, 1943.

Sora, *Porzana carolina.*—Rare fall transient. Eight records of this species were made, all during September; the extreme dates being September 5, 1941 and 1948 and September 21, 1943.

Purple Gallinule, *Porphyrula martinica.*—Casual summer visitor. One individual was seen several times during the period June 24-26, 1947. This represents the second record of this species for Maryland.

*Florida Gallinule, *Gallinula chloropus.*—One bird caught in a banding trap on April 18, 1949, and another seen on June 9, 1949, are the only Refuge records.

Coot, *Fulica americana.*—Rare spring and fall transient. This species was observed 5 times during spring, 1 each being recorded on March 8, 1949, March 30, 1949, and April 5, 1945, 6 on April 14, 1942, and 1 on April 19, 1947 [2 on April 26, 1950.]. Scattered records of singles or pairs were made during the fall; the extreme dates being October 1, 1938 and November 26, 1947.

Semipalmated Plover, *Charadrius hiaticula.*—Very rare spring transient. A single bird was seen on May 3, 1945, and a flock of 5 on May 17, 1945.

*Killdeer, *Charadrius vociferus.*—Common spring and fall transient; uncommon summer resident. In spring, earliest arrival, January 29, 1947; median arrival, February 12 (8); migration peak, March 2 to March 20. In fall, migration peak, October 7 to November 23; median departure, December 13 (5); latest departure, December 22, 1946. The arrival of Killdeers in the spring was usually coincident with the first extended warm period. During migration Killdeers were observed as singles, pairs, or in small flocks. The largest flock observed in spring contained 26 birds and was seen on March 2, 1945. The two largest flocks in fall contained 11 birds each, and were recorded on October 12, 1946 and December 9, 1946. Following the nesting season the first flocks were generally seen in early July, the two earliest records being a flock of 9 on July 1, 1943 and a flock of 7 on July 2, 1943. A few Killdeers remained on the Refuge to nest each year. Four pairs were present in 1943 and again in 1944. In 1947 only 2 pairs were found.

*American Woodcock, *Philohela minor.*—Common transient and resident in spring; uncommon summer resident and fall transient. In spring, earliest arrival, January 25, 1949 [January 23, 1950]; median arrival, February 15 (7); migration peak, February 26 to March 8. In fall, migration peak, October 31 to November 24; median departure, November 26 (6); latest departure, December 5, 1941. Spring migration usually extended from about February 15 to March 15. Occasionally during early prolonged warm spells the first arrivals appeared before this. January spring arrivals in 1944, 1947, and 1949 occurred during prolonged, unseasonable warm periods. On March 4, 1945, during the height of migration, 19 were recorded during a walk of one-half mile at dusk. The highest fall daily count was 8 birds seen on November 12, 1947. Between 17 and 23 pairs remained on the Refuge to nest each year. Most of these birds apparently stayed for only a short time after raising their young, as Woodcock appeared to be relatively scarce during the summer.

Wilson's Snipe, *Capella gallinago.*—Uncommon spring transient; very rare fall transient and winter visitor. In spring, earliest arrival, March 4, 1945; median arrival, March 21 (6); migration peak, March 20 to April 23; median departure, April 26 (5); latest departure, May 18, 1947. In fall, earliest arrival, September 17, 1943; latest departure,

November 24, 1936. Snipe occurred regularly in small numbers during the spring migration. Eight birds observed on April 14, 1946, was the largest number seen in one day. Four records, all of single birds, were made during the fall. Single birds seen on January 14, 1949, February 2, 1948, and February 16, 1949, represent the only winter records.

*Upland Plover, *Bartramia longicauda*.—Very rare spring and fall transient. Single birds were recorded on the following dates: March 25, 1944, May 10-11, 1941, and September 4, 1942 (collected).

*Spotted Sandpiper, *Actitis macularia*.—Common spring transient; uncommon fall transient. In spring, earliest arrival, April 5, 1945; median arrival, April 17 (7); migration peak, April 30 to May 15; median departure, May 30 (7); latest date of departure, June 6, 1945. In fall, earliest arrival, July 1, 1948; median arrival, July 8 (7); migration peak, July 25 to September 4; median departure, September 11 (4); latest departure, October 1, 1944. This species was found as scattered birds or in small groups. In spring, as many as 6 to 15 were often seen in a day, and one record of 24 birds was made on April 30, 1945. In fall, usually not over 3 birds were seen in one day, although occasionally, counts of up to 14 birds were made.

*Solitary Sandpiper, *Tringa solitaria*.—Uncommon spring transient; rare fall transient. In spring, earliest arrival, April 15, 1945; median arrival, April 30 (5); migration peak, May 1 to May 14; median departure, May 17 (6); latest departure, May 27, 1945. In fall, earliest arrival, July 12, 1948; median arrival, July 27 (6); median departure, September 15 (5); latest departure, September 27, 1948 [October 14, 1949]. In spring Solitary Sandpipers were found as singles or pairs, or occasionally in small groups comprising up to 13 (May 12, 1945) individuals. In fall not over 3 were recorded at one time.

*Greater Yellow-legs, *Totanus melanoleucus*.—Uncommon spring transient; rare fall transient. In spring, earliest arrival, March 25, 1944; median arrival, April 8 (4); migration peak, April 20 to May 13; median departure, May 19 (3); latest departure, May 24, 1945. In fall, earliest arrival, September 13, 1945; median arrival, September 21 (4); median departure, October 29 (3); latest departure, October 31, 1944 [November 20, 1949]. In the spring this species was usually seen as singles or in small groups comprising from 2 to 7 individuals. Not over 2 individuals were seen at one time in fall.

*Lesser Yellow-legs, *Totanus flavipes*.—Rare spring transient; very rare fall transient. In 1945, 1 to 7 birds were seen on the Refuge from April 21 to May 20. Other spring observations were on April 29, 1947 (1); May 2, 1949 (3); May 10, 1948 (2); May 12, 1949 (1); and May 23 and May 24, 1948 (1). One bird seen on August 12, 1947, a flock of 5 on August 15, 1948, and 1 on September 4, 1947, represent the only fall records [Three additional records during fall of 1949, including one on October 14.].

Pectoral Sandpiper, *Erolia melanotos*.—Very rare fall transient. One bird was seen on September 13, 1946, and another on November 12, 1945 [Three on October 2, two on October 3, and one on November 10, 1949.].

White-rumped Sandpiper, *Erolia fuscicollis*.—[Very rare fall transient. One was observed on October 2, 1949.]

*Least Sandpiper, *Erolia minutilla*.—Rare or uncommon spring transient; very rare fall transient. This species occurred on the Refuge in 1945 from May 3 to May 21, and in 1948, from May 9 to 24. The numbers recorded at one time ranged from 1 to 18. Three birds seen (1 collected) on August 12, 1948 and 1 seen on September 13, 1945 represent the only fall records [Single birds seen on October 2 and 3, 1949.].

*Red-backed Sandpiper, *Erolia alpina*.—Very rare spring transient. One bird was collected on May 5, 1945.

*Dowitcher, *Limnodromus griseus*—Very rare spring transient. One was collected on April 30, 1945.

Semipalmated Sandpiper, *Ereunetes pusillus*.—Very rare fall transient. One bird was seen on August 12, 1948.

Western Sandpiper, *Ereunetes mauri.*—[Very rare fall transient. One individual with typical long bill was closely observed on October 2, 1949.]

*Sanderling, *Crocethia alba.*—Very rare fall transient. One was collected on July 27, 1948.

Herring Gull, *Larus argentatus.*—Rare winter and spring visitor; very rare fall visitor. This species was observed irregularly in winter and spring from January 1 (1946) to April 25 (1944). The numbers recorded at one time ranged from 1 to 34. In the fall it was recorded on two dates: November 12, 1945 (1) and November 28, 1945 (5).

Ring-billed Gull, *Larus delawarensis.*—Rare winter and spring visitor [Very rare fall visitor.]. This species was recorded irregularly from January 23 (1945) [January 12, 1950] to April 12 (1943) [Three on November 19, 1949.]. The numbers observed at one time ranged from 1 to 6 individuals.

Bonaparte's Gull, *Larus philadelphia.*—Very rare spring and fall transient. Single birds were seen on March 31, 1949, April 15, 1948, [April 30, 1950] and November 26, 1947.

*Common Tern, *Sterna hirundo.*—Very rare spring transient. Single birds were seen on April 21, 1940 [One on April 30, 1950] and on May 5, 1948 and 2 birds (1 collected) on May 7, 1948.

*Black Tern, *Chlidonias niger.*—Very rare fall transient [and spring transient.]. One immature bird was observed on August 21, 1943. [One adult collected on April 29, 1950.]

*Mourning Dove, *Zenaidura macroura.*—Common permanent resident. During the late summer, fall, winter, and early spring doves frequently occurred in flocks comprising up to 50 or more individuals. The largest flock recorded contained 115 birds and was seen on September 28, 1946. One unusually late flock of 9 birds was seen on May 23, 1944. During late spring and early summer doves generally occurred in pairs or in small family groups. The Refuge breeding population in 1943 was approximately 32 pairs. Wintering populations in 1943-44 and 1944-45 were 133 and 119 individuals respectively. The winter survey totals, which show considerable yearly variations, are listed as follows: 1941-42, 49; 1943-44, 26; 1944-45, 157; 1945-46, 72; 1946-47, 16; 1947-48, 94; and 1948-49, 82 [1949-50, 173].

*Yellow-billed Cuckoo, *Coccyzus americanus.*—Common spring transient and summer resident; uncommon fall transient. In spring, earliest arrival, April 29, 1948; median arrival, May 2 (7); migration peak, May 9 to May 25. In fall, migration peak, August 16 to September 5; median departure, September 24 (5); latest departure, October 15, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 2 (7/27-8/16); 1, 1 (8/17-8/31); 1, + (9/1-9/9); 0, 1 (9/10-9/23); 2, 2 (5/5-5/11); 5, 2 (5/12-5/31); 3, 0 (6/1-6/26); 2, 5 (6/27-7/26). The largest number recorded in one day during the spring flight was 7 on May 9, 1943, and again on May 12, 1944. The largest number recorded in one day in fall was 8 on August 16, 1943. The breeding population in 1943 was approximately 75 pairs.

*Black-billed Cuckoo, *Coccyzus erythrophthalmus.*—Uncommon spring transient; rare fall transient; very rare (occasionally uncommon) summer resident. In spring, earliest arrival, April 25, 1944; median arrival, May 3 (7); migration peak, May 5 to May 18; latest departure, June 7, 1945. In fall, earliest arrival, August 17, 1946 and 1947; migration peak, August 17 to August 24; median departure, September 26 (3); latest departure, October 19, 1947. The largest number recorded in one day during the spring migration was 7 on May 8, 1943. Not over 2 birds were seen in one day during the fall flight. The Refuge breeding population varied considerably from year to year. During the summer of 1943, about 12 pairs were present, while in 1944, 1945, and 1946, Black-billed Cuckoos were either very rare or absent. In 1947, 1948 and 1949 several pairs were again present.

Barn Owl, *Tyto alba.*—Rare spring visitor; very rare summer visitor. Eleven birds (including 6 trapped) were recorded during the spring, extreme dates being March 19

(1944) and May 24 (1944). Single birds were also trapped on July 19 and July 22, 1944.

*Screech Owl, *Otus asio*.—Rare late summer and fall visitor; very rare winter visitor. A small number of Screech Owls visit the Refuge each year during the late summer and fall. The records were fairly evenly distributed between July 29 and November 1. Three winter records were also made on December 4, 1946, December 28, 1945, and January 8, 1945.

*Horned Owl, *Bubo virginianus*.—Rare permanent resident. One or 2 pairs were found on or near the Refuge throughout the year. Apparently the Horned Owl population is increased each year during the last half of November and first half of December. In 1946 this influx was especially noticeable, as 5 individuals were trapped between November 19 and December 8; no others were caught in the same number of traps set for several months before and after this period.

*Barred Owl, *Strix varia*.—Common permanent resident. When Barred Owls were hooting it was not unusual to record from 5 to 10 individuals in one evening. The Refuge breeding population in 1943 was 11 pairs. Average winter populations (as determined from banding data) in 1943-44 and 1944-45 were 25 and 18 individuals respectively.

Long-eared Owl, *Asio otus*.—Very rare spring visitor. Single individuals were recorded on the Refuge on the following dates: February 26, 1946; March 6, 1947 (trapped); March 10, 1947 (trapped); and April 19-23, 1944 (trapped).

*Saw-whet Owl, *Aegolius acadica*.—Very rare spring and fall visitor. One was trapped on March 30, 1944, another was seen on October 15, 1944, and a third was trapped on November 9, 1944.

*Whip-poor-will, *Caprimulgus vociferus*.—Common spring transient; uncommon summer resident and fall transient. In spring, earliest arrival, March 27, 1945; median arrival, April 14 (7); migration peak, April 20 to May 10. In fall, median departure, September 20 (6); latest departure, September 27, 1944. During the height of the spring migration as many as 7 could be heard from one location [24 recorded on entire Refuge on May 6, 1950]. In fall usually not more than 1 bird was heard in an evening. This apparent difference in relative abundance between spring and fall, may be due in large part to the greater conspicuousness of this species in spring. The Refuge breeding population in 1943 was approximately 15 pairs.

Nighthawk, *Chordeiles minor*.—Common or uncommon fall transient; rare spring transient; very rare summer resident. In spring, earliest arrival, May 3, 1943; median arrival, May 7 (4); migration peak, May 12 to May 25; latest departure, May 25, 1944. In fall, earliest arrival, July 17, 1944; median arrival, August 8 (4); migration peak, August 26 to September 4; median departure, September 28 (5); latest departure, October 5, 1944. During the fall flight, flocks of from 6 to 25 individuals were fairly frequent, and occasionally much larger flocks flew over. The two largest flocks, containing at least 200 individuals each, were seen on September 2, 1943 and on September 4, 1942. During the spring flight only occasional singles or pairs were recorded. The Refuge area was usually within the feeding territory of 1 pair each summer, although there was no evidence that the species actually nested within the Refuge boundary.

*Chimney Swift, *Chaetura pelagica*.—Common spring and fall transient, uncommon summer resident. In spring, earliest arrival, April 5, 1945; median arrival, April 12 (7); migration peak, April 16 to April 29. In fall, [earliest arrival, August 28, 1949] migration peak, September 17 to October 2; median departure, October 10 (7); latest departure, October 13, 1945 and 1946. Seasonal population indices for the years 1943-44 and 1944-45 were: 27, 12 (7/27-8/17); 2, 19 (8/18-9/8); 22, 36 (9/9-9/18); 291, 161 (9/19-9/24); 26, 94 (9/25-10/2); 3, 13 (10/3-10/9); 3, 6 (4/14-4/22); 37, 19 (4/23-4/30); 20, 19 (5/1-5/25); 10, 8 (5/26-7/19); 12, 25 (7/20-7/26). This is one of the few species that was frequently found in flocks during practically its entire stay in the region. Family groups could be recognized for only a few days after the young left the nest. Nearly all of the large flocks (over 25 birds) were seen in the fall.

The two largest recorded contained 400 and 135 birds respectively, and were both seen on September 23, 1943 [flock of 300 on August 28, 1949.]. On October 10, 1945, scattered individuals were observed migrating overhead at the rate of about 1 bird a minute. The only spring count of over 50 birds was made on April 29, 1945, when a flock of 225 was seen. The nesting population in 1943 was approximately 16 pairs.

*Ruby-throated Hummingbird, *Archilochus colubris*.—Common summer resident and fall transient; uncommon spring transient. In spring, earliest arrival, April 25, 1945; median arrival, April 30 (7). In fall, migration peak, August 21 to September 6; median departure, September 20 (4); latest departure, September 26, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 4 (7/27-8/1); 1, 6 (8/2-8/28); 3, 12 (8/29-9/6); 1, 1 (9/7-9/9); 1, 2 (4/26-5/6); 4, 5 (5/7-7/26). The largest numbers recorded in one day during the spring and fall flights were 9 on May 22, 1945, and 16 on August 29, 1944. The approximate nesting population in 1943 was 64 pairs.

*Belted Kingfisher, *Megaceryle alcyon*.—Rare summer resident and spring and fall transient; very rare winter resident. Usually seen as singles, this species was not common at any time. Probably 4 or 5 adults would represent the maximum number present on the Refuge at any one time during the spring, summer, and fall, and usually not over 2 could be found. During the past 8 years the Kingfisher remained on the Refuge during each of the following 4 winters: 1939-40, 1940-41, 1941-42, and 1943-44. Apparently only one bird wintered in each case. Following three winters during which it was absent (1945, 1946, and 1947), this species was first recorded in spring on March 3, March 8, and March 24, respectively. Preceding these winters it was last seen on October 29, 1944, November 18, 1945, and October 31, 1946, respectively.

*Flicker, *Colaptes auratus*.—Common spring and fall transient; uncommon winter resident; rare summer resident. In spring, earliest arrival, March 13, 1945; median arrival, March 18 (3); migration peak, March 20 to April 23; median departure, April 30 (3); latest departure, May 2, 1944. In fall, earliest arrival, September 23, 1943 and 1944; median arrival, September 23 (3); migration peak, September 28 to October 15; latest departure, November 17, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 2 (7/27-9/22); 16, 13 (9/23-11/13); 6, 8 (11/14-3/17); 11, 31 (3/18-3/24); 10, 4 (3/25-4/12); 7, 1 (4/13-4/30); +, 1 (5/1-5/22); 0, 0 (5/23-7/4); 2, 2 (7/5-7/26). During the fall, winter, and early spring Flickers commonly occurred in flocks. Most of these flocks were composed of less than 12 individuals but occasionally much larger numbers were seen. One flock of over 200 birds was observed on October 15, 1942. Another flock of 75 was seen on December 23, 1941, and one of 53 on December 29, 1944. During late spring and summer, Flickers were usually seen as singles or pairs. The nesting populations during 1943 and 1944 were 2 and 4 pairs, respectively. Refuge wintering populations during 1943-44 and 1944-45 were approximately 26 and 91 individuals, respectively. A considerable yearly variation in winter populations is further indicated by the following winter survey totals: 1941-42, 75; 1943-44, 24; 1944-45, 53; 1945-46, 44; 1946-47, 15; 1947-48, 6; and 1948-49, 30.

*Pileated Woodpecker, *Dryocopus pileatus*.—Rare permanent resident. The Refuge population during the period 1942 to 1948 averaged about 3 adults. A noticeable increase was apparent in 1949, when 4 pairs were present. The records were all of single birds or pairs except for a few observations of family groups in mid-summer.

*Red-bellied Woodpecker, *Centurus carolinus*.—Common permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 2 (7/27-8/14); 4, 4 (8/15-2/14); 4, 3 (2/15-7/14); 2, 3 (7/15-7/26). The Red-bellied Woodpecker population remained relatively static throughout the year as indicated by the seasonal population indices. The period July 15-August 14 probably represented the moulting season for this species; like most other birds the Red-belly is presumably more secretive and quiet while moulting, which would account for the low indices during this period. This species was generally observed as single birds or pairs, and occasionally in small groups comprising up to 5 individuals. The approximate nesting population in 1943 was 69 pairs. The approximate wintering populations in 1943-44 and 1944-45

were 40 and 52 individuals, respectively. Yearly variation in winter populations was usually comparatively slight, as is indicated by the following winter survey totals: 1941-42, 32; 1943-44, 27; 1944-45, 38; 1945-46, 30; 1946-47, 20; 1947-48, 10; and 1948-49, 21 [1949-50, 56].

Red-headed Woodpecker, *Melanerpes erythrocephalus.*—Rare fall transient; very rare winter resident and spring transient. A regular, although small fall migration occurred every year during the last half of September and early October. The first observations for the fall of 1943, 1944, and 1945 were recorded on September 9 (earliest fall record), September 15 and September 13, respectively. The two latest records of migrants were October 7, 1944, and October 9, 1943. Evidence of a very slight spring migration during the middle of May is indicated by the following dates of occurrence: May 12, 1946; May 13, 1943; May 14, 1943; May 16, 1943; and May 16, 1944. Not over 1 or 2 individuals were seen at one time during the migration. This species winters irregularly on the Refuge. The wintering populations during 9 consecutive years are shown as follows: 1940-41, 7; 1941-42, 1; 1942-43, 0; 1943-44, 0; 1944-45, 1; 1945-46, 0; 1946-47, 0; 1947-48, 0; and 1948-49, 0. The earliest record of a wintering bird was made on November 2, 1944 and the latest on April 13, 1941.

*Yellow-bellied Sapsucker, *Sphyrapicus varius.*—Uncommon fall transient; rare winter resident and spring transient. In spring, earliest arrival, March 20, 1941; median arrival, March 23 (4); migration peak, March 23 to April 9; median departure, April 23 (5); latest departure, April 30, 1944. In fall, earliest arrival, September 21, 1944; median arrival, September 26 (7); migration peak, September 26 to October 3. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 7 (9/27-10/3); 2, 1 (10/4-10/20); 0, 3 (10/21-12/23); +, 2 (12/24-2/14); +, 0 (2/15-3/19); 2, 1 (3/20-4/9); 1, 0 (4/10-4/30). During the fall migration, sapsuckers were sometimes observed in small loose flocks. On October 3, 1942, 5 were observed together in a large tree. In winter and spring usually only single birds were recorded. The highest number found in one day in fall was 7 on September 28, 1944, and on October 2, 1944. The largest number seen in one day in spring was 3 on March 26, 1944, April 6, 1945, and April 19, 1947. Refuge wintering populations during 1943-44 and 1944-45 were approximately 7 and 24 individuals respectively. Yearly variation in wintering populations is further indicated by the following winter survey totals: 1941-42, 4; 1943-44, 3; 1944-45, 11; 1945-46, 6; 1946-47, 3; 1947-48, 4; and 1948-49, 0.

*Hairy Woodpecker, *Dendrocopos villosus.*—Uncommon permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: +, + (7/27-8/24); 3, 2 (8/25-10/14); 1, 1 (10/15-12/4); 4, 2 (12/5-2/24); 1, 2 (2/25-7/4); +, 2 (7/5-7/26). The low index figures during the period July 27-August 24 were probably due to increased secretiveness of the birds while moulting. Except during the late spring and early summer when family groups were sometimes seen, Hairy Woodpeckers were usually observed as single birds or pairs. The approximate nesting population in 1943 was 17 pairs. Wintering populations during 1943-44 and 1944-45 were approximately 27 and 23 individuals respectively. Yearly variation in populations is indicated by the following winter survey totals: 1941-42, 9; 1943-44, 13; 1944-45, 13; 1945-46, 22; 1946-47, 15; 1947-48, 18; and 1948-49, 8.

*Downy Woodpecker, *Dendrocopos pubescens.*—Common permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: 4, 5 (7/27-9/4); 7, 6 (9/5-11/24); 13, 9 (11/25-3/4); 6, 8 (3/5-7/26). Although Downy Woodpeckers are most commonly observed as single birds or pairs, they were occasionally found in small groups. The largest aggregation recorded was 7 birds on January 7, 1944. The 1943 nesting population was approximately 58 pairs. Refuge wintering populations in 1943-44 and 1944-45 were approximately 120 and 111 individuals respectively. Yearly variation in population is indicated by the following winter survey totals: 1941-42, 42; 1943-44, 71; 1944-45, 69; 1945-46, 84; 1946-47, 73; 1947-48, 50; and 1948-49, 38 [1949-50, 100].

*Eastern Kingbird, *Tyrannus tyrannus.*—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, April 19, 1941, 1946, and 1947; median

arrival, April 24 (9); migration peak, May 2 to May 18. In fall, migration peak, August 9 to August 25; median departure, September 9 (8); latest departure, October 5, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 8, 6 (7/27-8/11); 9, 2 (8/12-8/25); 3, 1 (8/26-9/5); 2, 3 (4/25-4/30); 9, 12 (5/1-5/4); 6, 5 (5/5-7/26). This species was occasionally seen in flocks during the spring migration. The largest were all recorded on May 3, 1948 and May 18, 1947, when several flocks of from 6 to 30 individuals were seen. The highest number of individuals seen in one day in spring was 76 on May 18, 1947; and in fall, 14 on August 17, 1944. The 1943 nesting population on the Refuge was approximately 14 pairs.

*Crested Flycatcher, *Myiarchus crinitus*.—Uncommon spring transient and summer resident; rare fall transient. In spring, earliest arrival, April 20, 1942; median arrival, April 27 (8); migration peak, May 6 to May 12; latest departure, May 12, 1945. In fall, migration peak, August 23 to September 9; median departure, September 17 (5); latest departure, September 26, 1942. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 1 (7/27-9/14); 3, 1 (4/25-5/4); 3, 5 (5/5-6/14); 1, 1 (6/15-7/26). The largest number recorded in one day in spring was 13 on May 7, 1943 [17 on May 6, 1950]; and in fall, 3 on September 9, 1944. The approximate nesting population in 1943 was 40 pairs.

*Eastern Phoebe, *Sayornis phoebe*.—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, March 5, 1945 and 1946; median arrival, March 14 (8); migration peak, March 16 to April 7; latest departure, April 30, 1945. In fall, earliest arrival, September 1, 1944; migration peak, September 23 to October 7; median departure, November 5 (5); latest departure, November 23, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 0 (7/27-8/29); 0, 4 (8/30-9/14); 5, 3 (9/15-10/12); 2, + (10/13-10/30); +, 1 (3/5-3/15); 9, 7 (3/16-4/9); 3, 4 (4/10-7/21); 0, 2 (7/22-7/26). The largest number recorded in one day in spring was 18 on March 16, 1945; and in fall, 13 on October 7, 1945. The number of nesting pairs on the Refuge in 1942 and 1943 was 11 and 15, respectively.

*Yellow-bellied Flycatcher, *Empidonax flaviventris*.—Very rare spring and fall transient. Three records of single birds were made in the spring: May 18, 1948; May 21, 1937 (collected); and May 24, 1945. Three records were also made in the fall: 1 collected on August 19, 1942; 1 seen on September 4, 1947; and 1 trapped and banded on October 2, 1946.

*Acadian Flycatcher, *Empidonax virescens*.—Common summer resident (no evidence of transients). In spring, earliest arrival, May 2, 1947; median arrival, May 4 (7). In fall, median departure, September 7 (6); latest departure, September 19, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 7, 9 (7/27-7/29); 1, 5 (7/30-8/26); 1, 1 (8/27-9/1); 7, 8 (5/5-5/23); 19, 19 (5/24-6/17); 9, 15 (6/18-7/26). During most years the fall migration was largely over by the first of September. In 1947, however, the southward migration was considerably delayed, for these birds were observed quite commonly up to September 17; and on September 19, the latest date for the Refuge, 5 were recorded. In 1945 a single bird was observed repeatedly up to September 15. The nesting population in 1943 was approximately 267 pairs.

*Alder Flycatcher, *Empidonax traillii*.—Very rare spring transient. Two records were made of this species, both in the spring: 1 was seen and heard singing on May 27, 1944 [single birds seen and heard singing on May 22 and May 29, 1950]; and 1 was collected on June 2, 1943.

*Least Flycatcher, *Empidonax minimus*.—Rare spring and fall transient; very rare summer resident. In spring, earliest arrival, April 28, 1943 and 1944; median arrival, May 6 (7); migration peak, May 6 to May 16; median departure, May 18 (4); latest departure, June 1, 1945. In fall, earliest arrival, August 19, 1943; median arrival, August 27 (4); migration peak, August 25 to September 11; median departure, September 18 (3); latest departure, September 25, 1943. This species was occasionally observed during each migration period. Not more than 2 were found in any one day. During June, 1947, at least 3 male Least Flyactchers remained on the Refuge much longer than

usual, and were heard singing as late as June 25. All 3 birds appeared to have established territories and gave every indication of being on their nesting ground. However, they were apparently unmated as no evidence of the presence of females was noted. Another bird remained well into June in a census area 12 miles south of the Refuge, although all previous summer records for the state are from the extreme western and northern sections. The record of a Least Flycatcher seen by Skaggs in Trumbull County, Ohio, on June 28 of the same year (Mayfield, *Audubon Field Notes* 1: 177), suggests that the southern occurrences of this species during the summer of 1947 were not entirely local in scope. During the summer of 1948, a singing bird was noted regularly on the Refuge through July 13. A nest found on the Refuge the following summer established the first Maryland breeding record east of the Appalachian Mountains, and represents a range extension of about 100 miles.

*Eastern Wood Pewee, *Contopus virens*.—Common fall transient; uncommon spring transient and summer resident. In spring, earliest arrival, April 26, 1945; median arrival, May 6 (5); migration peak, May 12 to May 23. In fall, earliest arrival, September 9, 1944; migration peak, September 9 to September 28; median departure, October 5 (6); latest departure, October 10, 1947. The spring migration merged almost imperceptibly into the period of summer residence so that it was quite difficult to delimit the two periods. Seasonal population indices for the years 1943-44 and 1944-45 were: 6, 5 (7/27-9/24); 2, 3 (9/25-10/2); 0, 1 (4/26-5/11); 5, 6 (5/12-7/26). High numbers recorded in one day during migration were 9 on May 18, 1947 and May 22, 1945; 11 on May 30, 1945; 15 on September 9, 1944; and 9 on September 13, 1943. The Refuge nesting population in 1943 was approximately 60 pairs.

*Olive-sided Flycatcher, *Nuttallornis borealis*.—Very rare spring and fall transient. This species was recorded on the Refuge as follows: during the spring migration on May 16, 1943, May 18, 1949, May 27, 1949, May 31, 1943, and June 10, 1945; during the fall migration on August 10, 1943 (collected); August 29, 1946; September 15, 1944; and September 16, 1944. All records were of single birds. Although Cooke lists only 7 spring and 4 fall records within a 20-mile radius of Washington, D. C., from 1881 to 1929, this species was recorded on the Refuge in 5 years out of 7. This probably is the result of intensive observation during the bird's migration period, rather than any change in status.

*Horned Lark, *Eremophila alpestris*.—Uncommon spring and fall transient; rare winter resident; very rare summer resident. In spring, earliest arrival, January 18, 1945; median arrival, January 22 (3); migration peak, January 27 to February 23; latest departure, February 27, 1945. In fall, earliest arrival, September 27, 1944; median arrival, October 1 (4); migration peak, October 8 to November 15; median departure, December 12 (3); latest departure, December 15, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 0 (7/27-9/25); 1, 4 (9/26-12/12); 0, + (12/13-1/19); 4, 4 (1/20-2/25); 1, 1 (2/26-7/2); 0, 0 (7/3-7/26). The population indices for the period February 26 to July 2 are comparatively high due to the presence within the census area of the only pair of Horned Larks which nested on the Refuge during those years. The period July 3 to September 25 apparently represented the period of post-breeding wandering, as the birds were seldom observed on the Refuge at this time. During fall, winter, and spring, Horned Larks were usually found in flocks comprising up to 15 individuals. The largest number recorded in one day during spring migration was 18 on January 28, 1944, and during fall migration, 18 on October 30, 1944. Immature birds occasionally flock together soon after leaving the nest. On June 6, a flock of 20 individuals, mostly immature birds, was seen. The total nesting population on the Refuge consisted of 1 pair each year during the 7-year period, 1943-1949. Average wintering populations during 1943-44 and 1944-45 were approximately 12 and 10 individuals respectively.

*Tree Swallow, *Iridoprocne bicolor*.—Common spring transient; rare fall transient. In spring, earliest arrival, March 22, 1945; median arrival, April 3 (9); migration peak, April 6 to April 25; median departure, May 10 (5); latest departure, May 16, 1945 [May 18, 1950]. In fall, earliest arrival, July 3, 1944 [June 21, 1950]; median arrival,

July 11 (5); migration peak, August 27 to September 25; latest departure, October 24, 1948. During the spring, Tree Swallows were commonly observed in flocks. These varied considerably in size, the 3 largest containing 300, 200, and 150 individuals. Usually not over 3 or 4 records of this species were made each fall. At this time the vast majority of birds follow the coast. The largest number seen in one day during the fall was 4 on September 23, 1943.

*Bank Swallow, *Riparia riparia*.—Uncommon spring transient; rare fall transient. In spring, earliest arrival, April 11, 1943; median arrival, April 14 (5); migration peak, April 26 to May 8; median departure, May 7 (6); latest departure, May 26, 1949. In fall, earliest arrival, July 6, 1944; median arrival, July 11 (4); median departure, August 27 (5); latest departure, September 6, 1947. Ordinarily, not more than 4 birds were observed at one time. Ten individuals on May 1, 1943 [14 on May 18, 1950] and 10 on August 27, 1948 [23 on August 4, 1949], represent the largest number recorded in one day during each migration period.

*Rough-winged Swallow, *Stelgidopteryx ruficollis*.—Uncommon spring transient; very rare fall transient. In spring, earliest arrival, March 31, 1948; median arrival, April 13 (7); migration peak, April 22 to May 2; median departure, May 5 (6); latest departure, May 21, 1937. In fall, earliest arrival, June 20, 1945; latest departure, August 3, 1945. Usually only 1 to 4 individuals were seen at one time in spring. The largest number recorded in one day was 15 on May 1, 1943. Only 9 records of from 1 to 4 individuals were made during the southward migration. Although this species was not found nesting on the Refuge, scattered pairs were recorded during the nesting season at suitable localities within 15 miles of the Refuge.

*Barn Swallow, *Hirundo rustica*.—Common spring and fall transient; uncommon summer resident. In spring, earliest arrival, March 29, 1948 [March 28, 1950]; median arrival, April 8 (9); migration peak, April 23 to May 4; latest departure, May 22, 1945. In fall, earliest arrival, July 2, 1945; median arrival, July 6 (3); migration peak, August 9 to August 28; median departure, September 6 (5); latest departure, September 20, 1948. Barn Swallows commonly occurred in flocks during migration. In spring, the larger flocks ranged in size from 40 to 140 individuals. The first indication of the fall flight generally occurred in early July, when family groups began to merge into flocks. The total number of pairs nesting on the Refuge in 1943 was 9, while in 1947, 13 pairs were present, and in 1949, 31 pairs nested.

*Cliff Swallow, *Petrochelidon pyrrhonata*.—Rare spring transient; very rare fall transient. In spring, earliest arrival, April 23, 1944; median arrival, May 2 (6); migration peak, May 1 to May 12; median departure, May 14 (4); latest departure, May 21, 1948. In fall, earliest arrival, August 3, 1943; latest departure, September 16, 1944. Although the main flight of Cliff Swallows passes far to the west of the Refuge the species occurred regularly in small numbers each spring. Usually, only 1 or 2 were seen at one time. The two largest counts in one day were 36 on May 12, 1945, and 20 on May 1, 1945. Six records were made in fall: August 3, 1943 (2), August 4, 1943 (1), August 5, 1943 (1), August 28, 1947 (5), August 29, 1947 (1), and September 16, 1944 (2).

*Purple Martin, *Progne subis*.—Common fall transient; uncommon spring transient; rare summer visitor. In spring, earliest arrival, March 25, 1945; median arrival, March 31 (8); migration peak, April 2 to April 21; median departure, May 16 (5); latest departure, May 24, 1942. In fall, earliest arrival, July 6, 1944; median arrival, July 20 (7); migration peak, July 26 to August 22; median departure, August 28 (6); latest departure, September 6, 1947. During the spring flights martins generally occurred in small flocks. The largest recorded at this time contained 40 birds and was seen on April 6, 1944. The fall flocks averaged much larger. The two largest, containing 200 and 140 birds, were seen on August 1, 1946, and August 19, 1947, respectively. During May and June a small number of martins (2 to 7 birds) sometimes visited the Refuge, and were usually seen in the vicinity of the "martin" houses. These birds often appeared to be interested in nesting but apparently were prevented from doing so by the ever-present Starling. The nearest established colony of martins was within 3 miles of the Refuge.

*Blue Jay, *Cyanocitta cristata*.—Common spring and fall transient; uncommon or common winter resident; uncommon summer resident. In spring, earliest arrival, April 14, 1945; migration peak, April 21 to May 6; median departure, May 13 (4); latest departure, May 18, 1947. In fall, earliest arrival, September 9, 1943; median arrival, September 25 (4); migration peak, September 28 to October 12; median departure, November 9 (3); latest departure, November 12, 1945. Seasonal population indices for the years 1943-44 and 1944-45 were: 4, 1 (7/27-9/8); 20, 6 (9/9-9/19); 58, 17 (9/20-10/1); 49, 84 (10/2-10/10); 31, 35 (10/11-11/1); 7, 16 (11/2-4/18); 6, 61 (4/19-4/28); 53, 28 (4/29-5/3); 7, 10 (5/4-5/18); 1, 1 (5/19-7/26). In summer, Blue Jays were observed as singles, pairs, or small family groups. During the fall they frequently occurred in flocks averaging 10 individuals each, with a maximum of 29. Winter flocks were generally somewhat smaller, although one group of 33 individuals was recorded. Migrating flocks in spring averaged 11 individuals, with a maximum of 29. The two largest counts in one day during the fall flight were 90 on September 28, 1946 and 92 on October 9, 1944. The two largest counts in spring were 73 on April 26, 1945 and 71 on May 2, 1944 [134 on May 6, 1950]. The approximate Refuge nesting population in 1943 was 25 pairs. Wintering populations during 1943-44 and 1944-45 were approximately 36 and 199 individuals respectively. Yearly variation is further indicated by the winter survey totals: 1941-42, 144; 1943-44, 6; 1944-45, 123; 1945-46, 162; 1946-47, 21; 1947-48, 23; and 1948-49, 20.

*American Crow, *Corvus brachyrhynchos*.—Common spring and fall transient and winter resident; uncommon summer resident. In spring, earliest arrival, February 15, 1941; median arrival, February 19 (3); migration peak, February 28 to March 14; median departure, April 1 (3); latest departure, April 9, 1945. In fall, earliest arrival, September 21, 1948; median arrival, October 9 (5); migration peak, October 26 to November 13. Seasonal population indices for the years 1943-44 and 1944-45 were: 7, 6 (7/27-9/24); 13, 16 (9/25-10/20); 33, 36 (10/21-11/11); 14, 19 (11/12-2/14); 19, 46 (2/15-3/15); 6, 8 (3/16-7/26). This species was decidedly gregarious except during the breeding season. The larger flocks, comprising from 12 to 200 individuals [flock of 240 on January 12, 1950.], were commonly seen during the spring and fall migration, and occasionally in winter. These large flocks generally first appeared in early October (earliest record was a flock of 92 on September 21, 1948). Large flocks were seen in the spring through the first half of March, but rapidly decreased in size during the latter half (latest record was a flock of 17 on April 16, 1945). Smaller flocks of from 4 to 10 individuals were much more common and were seen throughout the year. During the summer, many of these smaller flocks presumably represented family groups. The total nesting population in 1943 was approximately 16 pairs. Wintering populations in 1943-44 and 1944-45 averaged 66 and 76 individuals respectively.

Fish Crow, *Corvus ossifragus*.—Rare spring transient; very rare fall transient and winter visitor. This species was occasionally noted during the period February 18 to June 2. Only three observations were recorded in fall: flocks of 8 and 5 on October 14, 1947; 2 birds on November 3, 1943; and 1 on November 8, 1946. Two records were also made during the winter: 1 on January 6, 1946 and 1 on January 14, 1943. Five birds seen on April 13, 1947, represented the largest number recorded in one day in spring.

Black-capped Chickadee, *Parus atricapillus*.—Casual winter visitor. Two were observed closely and heard calling on February 13, 1946.

*Carolina Chickadee, *Parus carolinensis*.—Common permanent resident. The data from the studies on seasonal population fluctuation show that the numbers of Carolina Chickadees usually remained fairly constant throughout the year. Thirty-nine observed on December 28, 1945, was the highest number recorded in one day. The approximate Refuge nesting population in 1943 was 85 pairs. Wintering populations in 1943-44 and 1944-45 were approximately 198 and 108 individuals, respectively. Such a marked yearly variation is not indicated by the winter survey totals: 1941-42, 92; 1943-44, 79; 1944-45, 82; 1945-46, 107; 1946-47, 105; 1947-48, 119; and 1948-49, 116 [1949-50, 219].

*Tufted Titmouse, *Parus bicolor*.—Common permanent resident. This species is

similar to the Carolina Chickadee in that it normally showed comparatively little seasonal variation in population. Fifty-one titmice were observed on December 29, 1944, the largest number recorded in one day. The Refuge breeding population during the summer of 1943 was approximately 187 pairs. The Refuge winter populations during 1943-44 and 1944-45 were approximately 223 and 254 individuals respectively. Considerable yearly variation in population is indicated by the following winter survey totals: 1941-42, 53; 1943-44, 125; 1944-45, 135; 1945-46, 180; 1946-47, 99; 1947-48, 57; and 1948-49, 61.

*White-breasted Nuthatch, *Sitta carolinensis*.—Irregular, rare, or uncommon winter resident and spring and fall transient; very rare summer visitor. In spring, earliest arrival, March 5, 1945; migration peak, March 5 to April 7; latest departure, May 4, 1943. In fall, earliest arrival, September 16, 1948; median arrival, September 27 (6); migration peak, October 13 to October 30. The period of spring migration of this species was quite variable. In 1944 and 1945 migration started about March 10, and in 1943, 1944, and 1945, the migration period extended to May 4, May 2, and May 2, respectively. In 1941 and 1946, however, the latest records of migrating birds were made on March 23. Seasonal population indices for the years 1943-44 and 1944-45 were: +, + (7/27-9/27); 5, 0 (9/28-10/11); 8, 2 (10/12-12/9); 12, 1 (12/10-3/2); 10, 2 (3/3-3/20); 8, 0 (3/21-4/7); 3, 0 (4/8-5/2); +, + (5/3-7/26). Seventeen birds observed on November 16, 1943, and again on March 11, 1944, represent the largest number recorded in one day. Nine records of this species were made during the summer, all in late June and July. In 1943, 1944, and 1945 the first records occurred on July 1, July 1, and July 2, respectively. It is probable that these records represent birds that have wandered from nearby nesting areas. This species nests on the Piedmont 4 miles west of the Refuge; and also on the Coastal Plain green sand belt, which is about 5 miles to the south. Winter populations during 1943-44 and 1944-45 were approximately 73 and 7 individuals respectively. Considerable yearly variation in populations is indicated, and is further substantiated by the following winter survey totals: 1941-42, 16; 1943-44, 49; 1944-45, 0; 1945-46, 52; 1946-47, 7; 1947-48, 0; and 1948-49, 9.

*Red-breasted Nuthatch, *Sitta canadensis*.—Irregular, rare, or uncommon (sometimes absent) winter resident and spring and fall transient; casual summer visitor. In spring, migration peak, March 22 to April 7; median departure, May 5 (6); latest departure, May 23, 1949. In fall, earliest arrival, September 4, 1945 [September 1, 1949]; median arrival, September 8 (3); migration peak, September 23 to October 18. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 0 (9/9-9/19); 7, 0 (9/20-10/20); 2, 0 (10/21-4/7); +, 0 (4/8-4/29). The occurrence of one bird on July 22, 1943, was very unusual. Red-breasted Nuthatches were frequently found in flocks, the number observed at one time ranging from 1 to 9 with an average of 2. The Refuge winter population in 1943-44 was approximately 63 individuals. This species varied greatly in abundance from year to year. It was often fairly common every second year and was rare, very rare, or absent during the alternate years. This is indicated by winter survey totals and general observations during 9 consecutive winters: 1940-41 (rare); 1941-42, 37 (fairly common); 1942-43 (very rare); 1943-44, 25 (fairly common); 1944-45, 0 (absent); 1945-46, 22 (fairly common); 1946-47, 7 (rare); 1947-48, 0 (absent); and 1948-49, 1 (rare).

*Brown Creeper, *Certhia familiaris*.—Uncommon winter resident and spring and fall transient; casual summer visitor. In spring, earliest arrival, March 18, 1944; migration peak, March 29 to April 7; median departure, April 14 (7); latest departure, April 29, 1944. In fall, earliest arrival, September 22, 1942; median arrival, October 2 (7); migration peak, October 25 to November 10; median departure, November 12 (2); latest departure, November 16, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 0 (9/25-9/30); 4, 2 (10/1-10/8); 6, 4 (10/9-10/24); 6, 8 (10/25-11/10); 4, 2 (11/11-3/28); 5, 6 (3/29-4/7); 2, 1 (4/8-4/17); 5, 0 (4/18-4/29). One singing bird observed on June 2, 1944, represents a very unusual record of occurrence. Brown Creepers were occasionally found in small groups containing from 1 to 4 individuals. A flock of 6 birds on April 7, 1943 was the largest recorded.

The highest number observed in one day was 13 on January 16, 1948. Wintering populations in 1943-44 and 1944-45 were approximately 66 and 54 individuals respectively. A slight yearly variation is also indicated by the following winter survey totals: 1941-42, 24; 1943-44, 22; 1944-45, 13; 1945-46, 21; 1946-47, 10; 1947-48, 20; and 1948-49, 31 [1949-50, 42].

*House Wren, *Troglodytes aëdon.*—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, April 8, 1945; median arrival, April 18 (10); in fall, median departure, October 7 (5); latest departure, October 30, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 8, 10 (7/27-8/11); 6, 3 (8/12-9/10); 13, 7 (9/11-9/15); 4, 1 (9/16-10/10); 0, 4 (4/14-4/20); 1, 9 (4/21-4/25); 10, 10 (4/26-7/26). The highest number observed in one day during the fall migration was 13 on September 13, 1943. The Refuge nesting populations during the summers of 1943 and 1944 were approximately 19 and 20 pairs respectively.

*Winter Wren, *Troglodytes troglodytes.*—Uncommon fall transient; rare winter resident and spring transient. In spring, migration peak, April 15 to April 21; median departure, April 30 (6); latest departure, May 3, 1943 [May 10, 1950]. In fall, earliest arrival, September 23, 1948; median arrival, September 27 (6); migration peak, October 11 to November 9. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 2 (9/25-10/2); 3, 3 (10/3-10/19); 3, 5 (10/20-11/9); 1, 4 (11/10-12/20); 1, 1 (12/21-4/7); 2, 1 (4/8-4/29). The largest numbers recorded in one day for the spring and fall migration periods were 4 on April 21, 1944 [11 on April 27, 1950], and 10 on October 27, 1943. The total winter populations during 1943-44 and 1944-45 were approximately 20 and 29 individuals respectively. Yearly variation in wintering populations is indicated by the following winter survey totals: 1941-42, 9; 1943-44, 13; 1944-45, 19; 1945-46, 15; 1946-47, 15; 1947-48, 10; and 1948-49, 6.

*Bewick's Wren, *Thryomanes bewickii.*—Casual spring visitor. One adult male was collected on April 8, 1944. There are no nesting records for this part of the state although the species is a common breeding bird in the mountains 75 miles to the west.

*Carolina Wren, *Thryothorus ludovicianus.*—Uncommon permanent resident. The nesting population during the summer of 1943 was approximately 43 pairs. The Refuge wintering populations during 1943-44 and 1944-45 were approximately 48 and 24 individuals. The winter survey totals were as follows: 1941-42, 6; 1943-44, 15; 1944-45, 10; 1945-46, 21; 1946-47, 26; 1947-48, 40; and 1948-49, 9. The highest number observed in one day was 16 on January 16, 1948. The abundance of this species was controlled to a considerable degree by the severity of the winter weather. The winter survey totals show how the population built up gradually from 1941-42 to a peak in January 1948. This peak of abundance was general through the Middle Atlantic States. Prolonged cold and snowy weather in February drastically reduced the population; the severity of the decline is shown by the 1948-49 figure. Fifty miles south of the Refuge, where much of the February precipitation fell in the form of rain, there was no noticeable decrease in this species.

*Long-billed Marsh Wren, *Telmatodytes palustris.*—Very rare fall transient [and spring transient]. The only two records are 1 bird collected in a small, grassy marsh on October 4, 1947, and 1 seen on September 22, 1948 [2 seen on May 6, 1950]. The absence of this species as a regular transient or summer resident was due to the lack of suitable marshes.

*Short-billed Marsh Wren, *Cistothorus platensis.*—Rare spring transient; very rare fall transient and summer resident. From 1943 through 1947 six records were made in the spring during the period May 2 (1944 and 1947) to May 12 (1943). In 1943 one bird was collected on May 10 in a small wet meadow covering one-half acre, another was collected in the same spot on May 11, and still another was seen there on May 12. Apparently only one bird was present each day, for the area was covered thoroughly and no more were flushed. In the spring and early summer of 1948 a field of Orchard Grass (*Dactylis glomerata*) was particularly attractive to this species. Seven individuals were counted in 5 acres of this field on May 17; 4 were found on the following day, 2 or 3 were heard singing daily from May 19 through May 25, and 1 through June 8, the day

after the field was mowed. [Late summer records: two on August 8, 1950 and one on September 3, 1950.] The only fall records were made on September 28, 1944 (1), October 5, 1943 (2), and October 24, 1943 (1). Cooke lists only 3 spring and no fall records within a 20-mile radius of Washington, D. C., by 1929; the number of Patuxent records is believed due to more frequent observations in suitable habitats, not to an increase in abundance of the species.

*Mockingbird, *Mimus polyglottos*.—Uncommon permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 4 (7/27-8/22); 1, 4 (8/23-9/15); 9, 5 (9/16-10/15); 3, 5 (10/16-11/25); 2, 2 (11/26-3/6); 3, 6 (3/7-4/30); 5, 6 (5/1-7/1); 9, 7 (7/2-7/26). A definite influx of Mockingbirds was generally noticeable in the fall especially during the period September 10 to October 10, when small groups or flocks were sometimes observed. On September 12, 1946, a loose flock of 9 was seen, and on September 24, 1946, a flock of 12. The breeding population in both 1943 and 1944 was 5 pairs. Wintering populations during 1943-44 and 1944-45 were 7 and 11 individuals respectively. Yearly variation in wintering populations is indicated by the winter survey totals: 1941-42, 4; 1943-44, 8; 1944-45, 8; 1945-46, 14; 1946-47, 5; 1947-48, 7; and 1948-49, 7.

*Catbird, *Dumetella carolinensis*.—Common summer resident and spring and fall transient [casual winter resident]. In spring, earliest arrival, April 21, 1945; median arrival, April 27 (9); latest departure, May 12, 1944 and 1945. In fall, median departure, October 14 (8); latest departure, November 2, 1948 [November 20, 1949]. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 9 (7/27-10/7); 6, 0 (10/8-10/13); 6, 1 (4/29-5/8); 6, 4 (5/9-7/26). The highest number recorded in one day in spring was 18 on May 18, 1947 [53 on May 6, 1950.]. During late summer Catbirds were wide-ranging and were frequently found in areas that contained none during the nesting season. This period of local movement merged imperceptibly into the period of fall migration so that it was not possible to delimit the two. The Refuge nesting population in 1943 was approximately 125 pairs. [One was seen on January 20, 1950.]

*Brown Thrasher, *Toxostoma rufum*.—Uncommon summer resident and spring and fall transient; casual winter resident. In spring, earliest arrival, March 31, 1949; median arrival, April 8 (9). In fall, median departure, October 7 (5); latest departure, October 14, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 1 (7/27-10/13); 1, 1 (4/6-4/18); 2, 4 (4/19-4/27); 16, 1 (4/28-5/1); 2, 2 (5/2-7/26). The largest number recorded in one day was 16 seen on April 29, 1944, which undoubtedly represented the peak of migration that year. Two records of this species were made during the winter: 1 on January 10, 1940, and 1 on January 10, 1942. The nesting population in 1943 was approximately 11 pairs.

*Robin, *Turdus migratorius*.—Abundant fall transient; common spring transient and summer resident; rare (occasionally uncommon) winter resident. In spring, earliest arrival, January 21, 1944; median arrival, February 6 (6); migration peak, March 14 to April 9; median departure, April 26 (4); latest departure, May 2, 1944 and 1945. In fall, earliest arrival, September 23, 1943; migration peak, October 18 to November 1; latest departure, December 5, 1944. The time of the start of spring migration was apt to vary considerably from year to year, and was apparently dependent on weather conditions. During a mild winter a noticeable increase in Robins sometimes became apparent in late January, or early February, while in other years, with severe weather conditions, the start of migration was sometimes delayed an entire month. Usually during average years, it was found that migration gradually built up for about 2 weeks after its start and then remained more or less at peak conditions for about one month. Following this the numbers steadily declined with the latest migrating flocks sometimes lingering until early May. Seasonal population indices for the years 1943-44 and 1944-45 were: 44, 52 (7/27-8/18); 26, 17 (8/19-8/30); 10, 8 (8/31-10/7); 62, 34 (10/8-10/25); 108, 262 (10/26-11/3); 5, 21 (11/4-12/5); +, 4 (12/6-2/6); 6, 1 (2/7-2/26); 35, 62 (2/27-4/9); 24, 24 (4/10-7/26). The Robin population showed a noticeable increase from the middle of July until the middle of August, due in part to the increasing number

of young birds. Family groups were found for a short period but soon broke up as the young learned to care for themselves; thereafter progressively larger flocks were formed. The earliest large summer flock, containing approximately 100 birds, was recorded on July 9, 1945. From the middle of August until early October, the flocks became more and more restless and tended to range over much larger areas. In September there was a noticeable slump in the population, presumably due to a movement to more favorable habitats outside of the Refuge. During late summer and early fall the average size of flocks was about 7 individuals (38 flocks). Migrating flocks in fall ranged in size from 4 to 110 individuals and averaged 17 (28 flocks). When migrating in the spring Robins almost always occurred in flocks which ranged in size from 4 to 150 individuals and averaged 9 individuals (83 flocks); the larger flocks usually occurring only during the peak of migration. The highest numbers of individuals seen in one day during migration were 400 on March 14, 1947, and 344 on October 26, 1944.

The breeding population on the Refuge during the summer of 1943 was approximately 25 pairs. Observations indicated that there was less yearly variation in the Refuge population at this season than at any other. The winter population of Robins varied considerably from year to year. During the winters of 1943-44 and 1944-45 the average populations on the Refuge at one time were approximately 2 and 20 individuals respectively. This variation is further indicated by the following winter survey totals: 1941-42, 15; 1943-44, 0; 1944-45, 25; 1945-46, 5; 1946-47, 1; 1947-48, 0; and 1948-49, 157. Much of this fluctuation in wintering populations was apparently due to yearly variation in food supply since there seemed to be a direct correlation between the number of Robins present and the quantity of suitable foods available. Wintering Robins were on the move most of the time and seldom remained in one area for more than 2 or 3 days. They occurred as singles, pairs, or small flocks (3-15), and rarely, during emergency weather conditions, or exceptionally open winters, could be seen concentrated in much larger numbers (50-100) in areas with a plentiful food supply. During the entire winter of 1948-49 (one of the warmest on record), Robins remained in abundance and flocks of up to 100 birds were seen on numerous occasions.

*Wood Thrush, *Hylocichla mustelina*.—Common summer resident and spring and fall transient. In spring, earliest arrival, April 20, 1941; median arrival, April 26 (9); migration peak, May 2 to May 16; median departure, May 16 (3); latest departure, May 18, 1947. In fall, earliest arrival, September 1, 1943; migration peak, September 1 to September 16; median departure, October 9 (7); latest departure October 20, 1948. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 2 (7/27-8/31); 12, 9 (9/1-9/8); 1, 5 (9/9-9/19); 1, 3 (9/20-10/7); 3, 0 (4/29-5/1); 9, 4 (5/2-5/19); 4, 4 (5/20-7/8); 3, 3 (7/9-7/26). The highest numbers recorded in one day during the spring migration were 52 on May 6, 1945, and 50 on May 3, 1947 and May 6, 1943 [98 on May 6, 1950]; the highest count in fall was 22 on September 6, 1944. The approximate Refuge nesting population in 1943 was 290 pairs.

*Hermit Thrush, *Hylocichla guttata*.—Common fall transient; uncommon spring transient; rare or uncommon winter resident. In spring, earliest arrival, April 3, 1945; migration peak, April 6 to April 24; median departure, April 30 (5); latest departure, May 5, 1943 [May 13, 1950]. In fall, earliest arrival, September 28, 1943; median arrival, October 10 (6); migration peak, October 9 to October 27; latest departure, December 5, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: +, + (9/28-10/7); 7, 13 (10/8-11/10); +, 10 (11/11-12/5); +, 4 (12/6-1/8); +, 1 (1/9-4/2); 1, 8 (4/3-4/14); 5, 1 (4/15-4/30). Hermit Thrushes were usually seen as singles or in twos or threes. During the peak of the fall migration, however, small groups containing as many as 5 or 6 individuals were sometimes found. The highest number recorded in one day during the spring migration was 18 on April 6, 1945, and in fall, 22 on October 26, 1944. The Refuge wintering populations during 1943-44 and 1944-45 were approximately 13 and 54 individuals respectively. Yearly variation in wintering populations is further indicated by the winter survey totals: 1941-42, 8; 1943-44, 3; 1944-45, 34; 1945-46, 27; 1946-47, 3; 1947-48, 14; and 1948-49, 2.

*Olive-backed Thrush, *Hylocichla ustulata*.—Common fall transient; uncommon

spring transient. In spring, earliest arrival, May 2, 1943; median arrival, May 8 (5); migration peak, May 10 to May 20; median departure, May 24 (7); latest departure, June 5, 1945. In fall, earliest arrival, September 4, 1944; median arrival, September 13 (7); migration peak, September 16 to September 29; median departure, October 8 (6); latest departure, October 15, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 12 (9/4-9/12); 4, 2 (9/13-10/2); 0, 1 (10/3-10/9); 2, 0 (5/2-5/15); 2, 5 (5/16-5/25). During the fall migration Olive-backed Thrushes were frequently heard calling at night while flying overhead. Up to several dozen were thus often heard in one night during the period September 9 to September 29 inclusive; and smaller numbers (up to one dozen) from September 30 to October 10 [100 heard in one hour, flying overhead on September 29, 1949.]. A total of 41 Olive-backed Thrushes was trapped during the period September 11 to September 23. The largest number seen in one day during the spring was 22 on May 15, 1943 [66 on May 10, 1950]; and in the fall, 18 on September 6, 1944.

*Gray-cheeked Thrush, *Hylocichla minima*.—Uncommon spring and fall transient. In spring, earliest arrival, May 5, 1943; median arrival, May 7 (3); migration peak, May 14 to May 24; median departure, May 27 (7); latest departure, June 1, 1945. In fall, earliest arrival, September 9, 1946; median arrival, September 14 (7); migration peak, September 18 to October 2; median departure, October 13 (6); latest departure, October 19, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 0 (9/16-10/3); 1, + (10/4-10/13); 2, 2 (5/20-5/28). Like the Olive-backed Thrush this species was frequently heard calling while migrating overhead. In the fall, 100 or more in one night were sometimes counted during the period September 14 to September 29; and even as late as October 10, 1946, 7 were counted within 6 minutes. Fourteen Gray-cheeked Thrushes were trapped in the fall and over half of these were taken during the period September 22 to September 28. The largest number observed in one day was 7 on September 28, 1943. During the spring flight, at least 90 were heard migrating overhead during the evening of May 24, 1947. Not over 5 individuals of this species were seen in a single day during the spring flight.

*Veery, *Hylocichla fuscescens*.—Uncommon spring and fall transient. In spring, earliest arrival, April 25, 1944; median arrival, May 4 (6); migration peak, May 4 to May 12; median departure, May 19 (6); latest departure, May 27, 1943. In fall, earliest arrival, August 20, 1944; median arrival, September 2 (4); migration peak, September 2 to September 15; median departure, September 16 (7); latest departure, October 11, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 0 (8/28-9/4); 4, 2 (9/5-9/16); 2, 0 (4/25-5/1); 4, 1 (5/2-5/16). Six birds seen on May 9, 1943, was the largest number recorded in one day during the spring flight [15 recorded on May 10 and again on May 13, 1950.]. The largest number observed in one day in fall was 12 on September 5, 1943.

*Eastern Bluebird, *Sialia sialis*.—Common spring and fall transient; uncommon summer resident; uncommon (occasionally rare) winter resident. In spring, earliest arrival, February 4, 1944; median arrival, February 10 (3); migration peak, March 9 to March 22; latest departure, April 9, 1945. In fall, earliest arrival, September 16, 1943; median arrival, September 22 (3); migration peak, October 18 to November 11; latest departure, December 20, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 21, 13 (7/27-8/30); 11, 10 (8/31-9/15); 34, 29 (9/16-11/11); 9, 11 (11/12-2/22); 25, 18 (2/23-3/22); 10, 10 (3/23-4/9); 6, 8 (4/10-5/24); 11, 13 (5/25-7/11); 13, 22 (7/12-7/26). Except during the breeding season, Bluebirds were usually found in flocks. These averaged about 6 individuals for all seasons, although the larger flocks were generally seen only during migration. The largest flock recorded in spring contained 43 individuals, and was seen on March 6, 1940; while the largest in fall, comprising 48 individuals, was recorded on November 1, 1943. The highest number of individuals seen in one day in spring was 61 on March 22, 1944, and in fall, 95 on November 3, 1943. The nesting populations in 1943 and 1944 were 14 and 13 pairs respectively. Wintering populations during 1943-44 and 1944-45 were approximately 34 and 31 individuals. Yearly variation in numbers was sometimes noticeable as is evi-

denced by the following winter survey totals: 1941-42, 52; 1943-44, 32; 1944-45, 33; 1945-46, 68; 1946-47, 36; 1947-48, 2; and 1948-49, 16.

*Blue-gray Gnatcatcher, *Polioptila caerulea*.—Uncommon summer resident (no evidence of transients noted). In spring, earliest arrival, March 30, 1945; median arrival, April 8 (8). In fall, median departure, September 8 (4); latest departure, September 21, 1948. This species was recorded regularly from the time of its arrival until the last of June, but was quite rare during the remainder of the summer. Eight observations were recorded in July, 2 in August, and 4 in September. The highest count for one day was 11 on May 3, 1947. The Refuge nesting population in 1943 was approximately 9 pairs.

*Golden-crowned Kinglet, *Regulus satrapa*.—Abundant or common fall transient; common or uncommon (sometimes rare) winter resident and spring transient. In spring, earliest arrival, March 20, 1945; migration peak, April 3 to April 18; median departure, April 20 (5); latest departure, April 25, 1943 and 1944 [May 1, 1950]. In fall, earliest arrival, September 22, 1942; median arrival, October 2 (6); migration peak, October 18 to October 30; latest departure, December 5, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 17, 17 (10/5-10/9); 27, 34 (10/10-10/24); 56, 30 (10/25-11/8); 33, 14 (11/9-12/8); 54, 5 (12/9-1/6); 34, 3 (1/7-1/31); 18, + (2/1-3/5); 9, 0 (3/6-3/24); 8, 2 (3/25-4/1); 21, 3 (4/2-4/10); 2, 0 (4/11-4/25). Golden-crowned Kinglets were often found in small flocks during the greater part of their stay on the Refuge. These flocks usually averaged around 5 or 6 individuals, with the large ones containing 12 or 14. The highest one-day counts for each season were 70 on October 27, 1943, 149 on December 23, 1943, and 35 on April 7, 1944. The Refuge wintering populations during 1943-44 and 1944-45 were approximately 414 and 9 individuals respectively. Yearly variation in wintering populations is further indicated by the following winter survey totals: 1941-42, 170; 1943-44, 380; 1944-45, 46; 1945-46, 144; 1946-47, 198; 1947-48, 24; and 1948-49, 100. The wintering populations were not so stable as they were for most species since they showed a steady, definite decline as the season progressed.

*Ruby-crowned Kinglet, *Regulus calendula*.—Abundant or common fall transient; common (sometimes uncommon) spring transient; very rare (occasionally uncommon) winter resident. In spring, earliest arrival, March 25, 1945; median arrival, March 30 (7); migration peak, April 13 to April 25; median departure, May 5 (7); latest departure, May 10, 1947. In fall, earliest arrival, September 22, 1944; median arrival, September 28 (7); migration peak, October 12 to October 30; latest departure, November 13, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, + (9/22-10/6); 38, 10 (10/7-10/25); 110, 21 (10/26-11/1); 6, 0 (11/2-11/11); 0, 2 (11/12-11/29); 0, + (11/30-4/2); 1, 5 (4/3-4/18); 30, 7 (4/19-4/29); 3, 2 (4/30-5/2). Ruby-crowns frequently occurred in flocks during migration. These usually included from 5 to 10 individuals. The 3 largest flocks of 25, 20, and 20 individuals, were all seen on October 27, 1943. On this date a total of 155 was recorded, the largest number seen in one day. The largest one-day total in spring was 36 on April 21, 1944. Wintering populations in 1943-44 and 1944-45 were approximately 1 and 5 individuals respectively. During some years this species was entirely absent in winter. Some indication of yearly variation in wintering populations is shown by the following winter survey totals: 1941-42, 0; 1943-44, 2; 1944-45, 4; 1945-46, 0; 1946-47, 3; 1947-48, 1; and 1948-49, 23. The high population throughout the winter of 1948-49 was a direct result of the unseasonably warm weather, and was noted throughout eastern Maryland and Virginia.

*American Pipit, *Anthus spinoletta*.—Uncommon spring and fall transient. In spring, earliest arrival, March 4, 1944 and 1945; median arrival, March 9 (4); migration peak, March 9 to March 20; median departure, March 26 (4); latest departure, May 18, 1949. In fall, earliest arrival, September 23, 1943; median arrival, October 6 (4); migration peak, October 13 to November 3; median departure, November 26 (5); latest departure, January 12, 1949. During most years the fall migration of pipits was over by late November. However, in 1944 and 1949, flocks were seen regularly through the greater part of December. Pipits were recorded as singles or pairs or in flocks comprising

up to 65 individuals in the spring (March 13, 1941) and up to 55 individuals in the fall (November 7, 1947). These were also the highest daily counts recorded.

*Cedar Waxwing, *Bombycilla cedrorum*.—Common spring and fall transient; rare or uncommon (sometimes absent) winter resident; rare summer resident. In spring, earliest arrival, April 29, 1945; median arrival, May 5 (8); migration peak, May 13 to May 22; median departure, June 2 (3); latest departure, June 8, 1945. In fall, earliest arrival, August 9, 1944; median arrival, August 17 (5); migration peak, October 21 to October 30; median departure, January 8 (6); latest departure, January 12, 1940. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, + (7/27-8/8); 7, 3 (8/9-8/24); 7, 24 (8/25-9/27); 5, 10 (9/28-10/25); 125, 138 (10/26-10/30); 2, 6 (10/31-12/17); 0, 35 (12/18-1/23); 0, 1 (1/24-2/24); 1, 7 (2/25-5/12); 23, 22 (5/13-5/22); 3, 1 (5/23-5/31); +, 0 (6/1-7/26). During migration, flocks of from 5 to 20 individuals were usually seen, although occasionally much larger groups were noted. The largest flock recorded in the fall contained 90 individuals, and was seen on October 26, 1944, while the largest wintering flock, comprising 50 individuals, was seen on March 15, 1945. In fall migration the average size of flocks was 21 individuals (82 flocks), while during winter and spring the average size was 16 individuals (60 flocks). The highest numbers of individuals observed in one day during spring and fall were 70 on May 18, 1947, and 268 on October 26, 1944. The nesting population was very small. In 1943 only 2 pairs were present. However, in 1945 there were at least 5 pairs on the Refuge. Although this species usually occurred on the Refuge every winter it was extremely erratic and flocks seldom remained in one area for more than a day or two. During 9 years (1940-1949) it was present on the Refuge each winter except in 1943-44 and 1947-48. The numbers present were usually small, although as many as 83 were recorded during the winter survey of 1944-45.

*Loggerhead Shrike, *Lanius ludovicianus*.—Rare spring and fall transient; very rare winter visitor. In spring this species was recorded from March 16 (1947) to April 14 (1946) inclusive, and in fall from August 12 (1943) to September 22 (1942). Usually not over 2 or 3 birds were seen during each migration period. Only 2 winter records were made, January 4, 1939 (1), and January 6, 1941 (1).

*Starling, *Sturnus vulgaris*.—Common permanent resident. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 10 (7/27-9/14); 15, 33 (9/15-12/24); 6, 9 (12/25-2/24); 14, 19 (2/25-7/26). Except during the breeding season Starlings usually occurred in flocks. In the summer these were first noted when the young birds left the nest. The earliest flock recorded was of 25 young birds on May 10, 1945. As the summer and fall progressed flocks continued to increase in size, reaching their peak during the winter, and then dropping off in the spring when nesting began. In winter the flocks usually averaged about 30 individuals and occasionally ranged up to 300 or 400. One very large flock containing at least 5,000 birds was seen on December 17, 1944. The Refuge nesting population in 1943 was 15 pairs. Wintering populations varied considerably from time to time as flocks were continually shifting their feeding areas.

*White-eyed Vireo, *Vireo griseus*.—Common summer resident and spring and fall transient. In spring, earliest arrival, April 16, 1948; median arrival, April 22 (9); migration peak, May 3 to May 9. In fall, earliest arrival, August 29, 1947; migration peak, August 29 to September 9; median departure, September 24 (6); latest departure, October 5, 1945. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 6 (7/27-9/6); 15, 2 (9/7-9/11); 3, 1 (9/12-9/23); 2, 6 (4/21-4/28); 12, 5 (4/29-5/12); 6, 5 (5/13-7/26). The highest spring counts were recorded on May 9, 1943 (13), May 5, 1944 (22), and May 6, 1945 (12) [May 6, 1950 (27)]. The largest fall counts were on September 9, 1943 (15), and September 6, 1944 (11). The approximate Refuge nesting population in 1943 was 112 pairs.

*Yellow-throated Vireo, *Vireo flavifrons*.—Uncommon spring transient and summer resident; rare or uncommon fall transient. In spring, earliest arrival, April 19, 1948; median arrival, April 25 (8); migration peak, May 6 to May 18. In fall, earliest arrival, August 28, 1943; median departure, September 24 (6); latest departure, September 29,

1941. Seasonal population indices for the years 1943-44 and 1944-45 were: +, + (7/27-8/27); 1, + (8/28-9/28); 1, 1 (4/21-4/28); 1, 3 (4/29-5/24); 2, 2 (5/25-7/26). The highest numbers recorded in one day in spring and fall were 10 on May 6, 1943 [19 on May 6, 1950] and 3 on August 28, 1943 and September 18, 1947. The approximate Refuge nesting population in 1943 was 50 pairs.

*Blue-headed Vireo, *Vireo solitarius*.—Uncommon or rare spring and fall transient. In spring, earliest arrival, April 14, 1945; median arrival, April 19 (7); migration peak, April 25 to May 5; median departure, May 6 (6); latest departure, May 30, 1947. In fall, earliest arrival, September 25, 1945; median arrival, October 2 (6); migration peak, October 2 to October 20; median departure, October 20 (6); latest departure, October 30, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, + (10/5-10/23); 0, 3 (10/24-10/30); 0, + (4/14-4/22); 5, 0 (4/23-5/2). The spring migration in 1943 was later than usual. During this year Blue-headed Vireos were observed regularly in fair numbers (3 to 7 each day) from April 28 to May 8 inclusive, and in smaller numbers up to May 12. In the spring of 1944 the largest number (10) was recorded on April 29. The spring migration in 1945 was very poor. During the fall flight the maximum number seen in a day was 20 on October 15, 1947.

*Red-eyed Vireo, *Vireo olivaceus*.—Abundant spring transient and summer resident; common fall transient. In spring, earliest arrival, April 18, 1945; median arrival, April 27 (8); migration peak, May 3 to May 16. In fall, median departure, October 7 (5); latest departure, October 17, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 37, 34 (7/27-8/26); 28, 6 (8/27-9/23); 1, 1 (9/24-10/7); 0, 8 (4/21-4/26); 25, 29 (4/27-5/4); 61, 70 (5/5-7/8); 34, 55 (7/9-7/26). The highest number of individuals recorded in one day during the spring migration was 205 on May 3, 1947, and in fall, 47 on September 5, 1943. The approximate Refuge nesting population in 1943 was 908 pairs. Breeding populations sometimes show considerable yearly variation. In 1944 the breeding population in bottomland forest was 55 pairs per 100 acres, while in 1945 it had increased to 92 pairs per 100 acres. The density in bluff forest in 1944 was 34 pairs per 100 acres, while in 1945 it had increased to 52 pairs per 100 acres. Thus these two habitats showed an increase of 67 percent and 53 percent respectively.

Philadelphia Vireo, *Vireo philadelphicus*.—Very rare spring and fall transient. Single birds were observed on the following dates: May 20, 1947; September 13, 1943; September 15, 1942; and September 20, 1944.

Warbling Vireo, *Vireo gilvus*.—Very rare summer visitor. One bird was seen and heard singing several times on June 11, 1946. This species nests locally in many parts of Maryland, but has not been found breeding in the vicinity of the Refuge in recent years.

*Black and White Warbler, *Mniotilta varia*.—Common spring and fall transient; uncommon summer resident. In spring, earliest arrival, April 8, 1948; median arrival, April 16 (10); migration peak, April 25 to May 8; latest departure, May 30, 1945. In fall, earliest arrival, August 6, 1943; median arrival, August 16 (4); migration peak, August 28 to September 5; median departure, October 3 (6); latest departure, October 17, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 1 (7/27-8/15); 11, 4 (8/16-8/26); 27, 8 (8/27-9/6); 9, 2 (9/7-9/28); +, 1 (9/29-10/9); 0, 3 (4/14-4/20); 12, 7 (4/21-5/23); 4, 2 (5/24-5/30); 1, 0 (5/31-6/29); 1, 3 (6/30-7/26). During migration Black and White Warblers frequently occurred in loose, mixed flocks with other species of woodland birds. The largest numbers recorded in single flocks during spring and fall were 7 and 12 respectively. The two highest daily counts during the spring migration were 45 on April 29, 1943, and 31 on April 29, 1944. The only daily count above 16 in the fall was 50 on August 28, 1943. The Refuge breeding population in 1943 was approximately 45 pairs.

*Prothonotary Warbler, *Protonotaria citrea*.—Rare summer resident. The earliest date of its occurrence on the Refuge in spring was April 21, 1949, and the latest in fall was on August 18, 1946 [August 31, 1949]. Apparently only 2 or 3 pairs nest on the

Refuge each year, although this species breeds fairly commonly along the Patuxent River 5 miles southeast of the Refuge.

*Worm-eating Warbler, *Helmitheros vermivorus*.—Rare spring and fall transient and summer resident. In spring, earliest arrival, April 28, 1944; median arrival, May 1 (6); migration peak, April 30 to May 6; latest departure, May 9, 1946 and 1948. In fall, earliest arrival, August 14, 1946; migration peak, August 21 to September 8; median departure, September 9 (5); latest departure, September 13, 1945. Three birds recorded on May 9, 1948, August 24, 1943, and August 28, 1943 represent the largest counts [Six on May 10, 1950.]. From 4 to 8 pairs nested on the Refuge each year. From late June until the start of the fall migration in mid-August, the few resident pairs and young were apparently very inconspicuous since none were recorded during this period.

*Golden-winged Warbler, *Vermivora chrysoptera*.—Uncommon spring transient; uncommon or rare fall transient. In spring, earliest arrival, April 25, 1946; median arrival, April 30 (7); migration peak, May 2 to May 9; median departure, May 11 (7); latest departure, May 12, 1937 and 1943 [May 16, 1950]. In fall, earliest arrival, August 22, 1948 [August 21, 1950]; median arrival, August 24 (5); migration peak, August 24 to August 28; median departure, September 3 (4); latest departure, September 7, 1942. Seventeen birds seen on May 8, 1943, and 13 on May 6, 1943, represent the highest numbers seen in one day during the spring migration. The two highest counts in fall were 14 on August 28, 1943, and 3 on August 24, 1943.

*Blue-winged Warbler, *Vermivora pinus*.—Rare or uncommon spring transient; rare fall transient. In spring, earliest arrival, April 28, 1943 and 1944; median arrival, May 1 (7); migration peak, May 2 to May 9; median departure, May 10 (6); latest departure, May 13, 1944 [May 17, 1950]. In fall, earliest arrival, August 11, 1943; median arrival, August 24 (4); migration peak, August 22 to September 5; median departure, September 13 (5); latest departure, October 4, 1947. Eleven birds seen on May 3, 1947, [17 on May 10, 1950] and 4 on August 24, 1942 and August 20, 1943, represent the highest numbers of individuals recorded in one day during the spring and fall migrations.

(Golden-winged Warbler-Blue-winged Warbler, Hybrids).—On May 8, 1943, a male and a female Brewster's Warbler (*Vermivora leucobronchialis*) were recorded together in a hedgerow. On September 4, 1942, a Lawrence's Warbler (*Vermivora lawrencei*) was seen in a hedgerow with a mixed flock of birds which included a Golden-winged Warbler and a Blue-winged Warbler

*Tennessee Warbler, *Vermivora peregrina*.—Rare or uncommon spring and fall transient [Common in spring of 1950.]. In spring, earliest arrival, May 8, 1948 [May 6, 1950]; median arrival, May 11 (4); migration peak, May 13 to May 18; latest departure, May 23, 1947. In fall, earliest arrival, September 6, 1944; median arrival, September 10 (6); migration peak, September 13 to October 3; median departure, October 3 (7); latest departure, October 16, 1947. Tennessee Warblers were usually recorded in small numbers during each migration period. The highest one-day counts were 12 on May 18, 1947 and 12 on October 3, 1947 [High 1950 spring counts: 13 on May 7; 21 on May 9; 57 on May 10; 36 on May 11; 54 on May 13; 66 on May 14.].

*Orange-crowned Warbler, *Vermivora celata*.—[Very rare fall transient. One collected on October 22, 1949.]

*Nashville Warbler, *Vermivora ruficapilla*.—Rare spring and fall transient. In spring, earliest arrival, April 23, 1946; median arrival, April 29 (5); migration peak, May 1 to May 8; median departure, May 14 (4); latest departure, May 25, 1949. In fall, earliest arrival, September 6, 1944; median arrival, September 13 (3); median departure, September 29 (4); latest departure, October 14, 1947. Nashville Warblers were recorded regularly in small numbers each spring, and rather irregularly in fall. The largest numbers seen in one day in spring were 4 on May 1, 1948 and May 6, 1943, and in fall, 3 on October 3, 1947.

*Parula Warbler, *Parula americana*.—Common summer resident and spring transient; uncommon fall transient. In spring, earliest arrival, April 14, 1945; median arrival,

April 18 (10); migration peak, April 23 to May 9; latest departure, May 30, 1944 and 1945. In fall, earliest arrival, September 9, 1943; migration peak, September 13 to October 3; median departure, October 6 (6); latest departure, October 17, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: +, + (7/27-8/5); 7, + (8/6-8/21); 1, 1 (8/22-9/7); 4, + (9/8-9/28); +, + (9/29-10/9); 0, 3 (4/14-4/20); 11, 8 (4/21-4/30); 24, 11 (5/1-5/9); 9, 9 (5/10-6/27); 4, 4 (5/28-7/10); +, 3 (7/11-7/26). The highest daily counts in spring and fall were 45 on May 3, 1947 [112 on May 6, 1950], and 17 on October 3, 1947, respectively. The approximate nesting population of the Refuge in 1943 was 205 pairs.

*Yellow Warbler, *Dendroica petechia*.—Rare or uncommon spring transient; very rare fall transient. In spring, earliest arrival, April 28, 1944; median arrival, April 30 (7); migration peak, April 30 to May 18; median departure, May 26 (9); latest departure, June 3, 1948. This species occurred regularly in small numbers in the spring when from 1 to 4 individuals were often found in a day during the migration peak. The highest number seen in one day was 8 on May 18, 1947. During the fall single birds were observed on the following dates: August 9, 1946; August 14, 1947; August 22, 1948; August 27, 1943; and September 19, 1943.

*Magnolia Warbler, *Dendroica magnolia*.—Common fall transient; uncommon spring transient [Common in spring of 1950.]. In spring, earliest arrival, May 3, 1947; median arrival, May 6 (6); migration peak, May 8 to May 18; median departure, May 24 (7); latest departure, June 3, 1945. In fall, earliest arrival, August 20, 1944; median arrival, August 28 (6); migration peak, September 13 to September 25; median departure, October 8 (6); latest departure, October 18, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 1 (8/21-8/28); 2, 3 (8/29-9/5); 14, 12 (9/6-9/14); 13, 1 (9/15-9/28); 1, + (9/29-10/18); 2, 2 (5/5-5/16); 0, 3 (5/17-5/30). Twenty-three birds seen on May 18, 1947 [69 on May 10, 1950.] constituted the largest number recorded in one day during the spring. The largest number found in one day in the fall was 29 on September 25, 1943.

*Cape May Warbler, *Dendroica tigrina*.—Common fall transient; rare spring transient [More common than usual in spring of 1950.]. In spring, earliest arrival, April 28, 1943; median arrival, May 8 (6); migration peak, May 9 to May 14; latest departure, May 20, 1945. In fall, earliest arrival, August 23, 1942; median arrival, September 12 (7); migration peak, September 11 to October 9; median departure, October 19 (6); latest departure, October 26, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 1 (9/1-9/8); 1, 9 (9/9-9/23); 12, 24 (9/24-10/1); 1, 28 (10/2-10/12); 1, 2 (10/13-10/26); 0, 1 (5/12-5/16). Usually not over 1 or 2 birds were found in a day during the spring migration of a normal year. The largest number seen in one day during the spring flight was 12 on May 9, 1943 [20 on May 10, 1950 and 21 on May 13, 1950.]. The 1944 spring flight was exceedingly poor; only 1 bird was recorded (May 7) during the entire period. The largest number recorded in one day in the fall was 41 on October 7, 1944.

*Black-throated Blue Warbler, *Dendroica caerulescens*.—Common or uncommon spring and fall transient [abundant in spring of 1950]. In spring, earliest arrival, April 25, 1944 and 1948; median arrival, April 30 (7); migration peak, May 3 to May 16; median departure, May 19 (8); latest departure, May 23, 1947 and 1949. In fall, earliest arrival, August 21, 1944; median arrival, September 2 (6); migration peak, September 25 to October 5; median departure, October 13 (7); latest departure, October 17, 1945. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 2 (8/21-9/5); 3, 3 (9/6-9/21); 5, 5 (9/22-10/5); 1, 2 (10/6-10/16); 5, 1 (4/29-5/8); 2, 9 (5/9-5/16). The largest number observed in one day in the spring was 20 on May 16, 1945 [high 1950 spring counts: 67 on May 7, 119 on May 10, 54 on May 13], and in the fall, 29 on October 11, 1947 (an unusually late season).

*Myrtle Warbler, *Dendroica coronata*.—Abundant spring and fall transient; uncommon or rare winter resident. In spring, earliest arrival, March 23, 1948; median arrival, April 5 (4); migration peak, April 17 to May 9; median departure, May 17 (6); latest departure, May 26, 1945. In fall, earliest arrival, September 19, 1948; median arrival,

September 26 (7); migration peak, October 7 to November 9; median departure, November 16 (3); latest departure, December 20, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 0 (9/28-10/1); 12, 36 (10/2-10/7); 39, 91 (10/8-11/4); 7, 39 (11/5-11/16); 2, 15 (11/17-12/23); 3, 8 (12/24-4/2); 6, 21 (4/3-4/15); 29, 62 (4/16-5/5); 0, 14 (5/6-5/12); 0, 2 (5/13-5/16). During the peak of migration in spring and fall 100 or more Myrtle Warblers were often seen in one day. The highest daily counts in spring and fall were 130 on April 21, 1945 [169 on May 13, 1950.], and 196 on October 26, 1944, respectively. Myrtle Warblers usually occurred in flocks either by themselves or mixed with other species. The average number in these flocks was between 7 and 8, with individual counts ranging from 2 to 3 individuals up to 50 or more. The Refuge wintering population was approximately 22 birds in 1943-44 and 106 in 1944-45. Yearly variation at this season is further indicated by the following winter survey totals: 1941-42, 215; 1943-44, 20; 1944-45, 55; 1945-46, 14; 1946-47, 38; 1947-48, 0; and 1948-49, 196. The absence of Myrtle Warblers during the winter of 1947-48 was correlated with a complete local crop failure of Poison Ivy (*Toxicodendron radicans*) fruit that year.

*Black-throated Green Warbler, *Dendroica virens*.—Common fall transient; common or uncommon spring transient. In spring, earliest arrival, April 19, 1946; median arrival, April 23 (8); migration peak, May 3 to May 9; median departure, May 19 (6); latest departure, May 30, 1945. In fall, earliest arrival, August 26, 1944 [August 21, 1949]; median arrival, September 5 (6); migration peak, September 9 to October 3; median departure, October 12 (5); latest departure, October 18, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 1 (9/1-9/8); 19, 8 (9/9-9/25); 10, 3 (9/26-10/7); 2, 1 (10/8-10/18); 1, 0 (4/25-4/28); 7, 1 (4/29-5/5); 2, 5 (5/6-5/16); 0, 1 (5/17-5/30). The highest daily counts in spring and fall were 28 on May 3, 1947 [37 on May 10, 1950.], and 28 on September 25, 1943.

*Cerulean Warbler, *Dendroica cerulea*.—Very rare spring and fall transient. This species was recorded only on May 6, 1948 (1), May 8, 1948 (3), May 8, 1943 (1), May 19, 1941 (1), May 31, 1949 (1), and August 25, 1942 (1).

*Blackburnian Warbler, *Dendroica fusca*.—Uncommon spring and fall transient [Common in spring of 1950.]. In spring, earliest arrival, April 25, 1944; median arrival, May 3 (7); migration peak, May 3 to May 18; median departure, May 21 (8); latest departure, June 4, 1945. In fall, earliest arrival, August 19, 1942 and 1944; median arrival, August 20 (5); migration peak, September 6 to September 23; median departure, September 19 (7); latest departure, October 4, 1946. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 0 (8/20-9/5); 4, 2 (9/6-9/23); 2, 0 (4/25-5/1); 8, 1 (5/2-5/10); 0, 1 (5/11-5/30). The highest number seen in one day in spring was 25 on May 8, 1943 [89 on May 10, 1950.], and in fall, 8 on September 11, 1943.

*Yellow-throated Warbler, *Dendroica dominica*.—Very rare spring visitor. This species, which breeds commonly to the northern limit of the Loblolly Pine country, 20 miles to the south and east of the Refuge, was recorded only once on the Patuxent Refuge. The one bird, a male, was collected on April 19, 1945.

*Chestnut-sided Warbler, *Dendroica pensylvanica*.—Common fall transient; uncommon or common spring transient [Abundant in spring of 1950.]. In spring, earliest arrival, April 25, 1948; median arrival, May 2 (8); migration peak, May 3 to May 16; median departure, May 16 (9); latest departure, May 27, 1949. In fall, earliest arrival, August 12, 1944; median arrival, August 19 (6); migration peak, August 20 to September 9; median departure, September 30 (6); latest departure, October 10, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 27, 4 (8/20-8/26); 11, 5 (8/27-9/11); 4, 3 (9/12-9/22); 1, 1 (9/23-9/25); 2, 3 (5/2-5/16). The highest number recorded in one day during the spring was 35 on May 9, 1943 [161 on May 10, 1950.], and in the fall, 32 on August 20, 1943.

*Bay-breasted Warbler, *Dendroica castanea*.—Uncommon fall transient; rare spring transient. [More common than usual in spring of 1950.]. In spring, earliest arrival, May

8, 1943 [May 7, 1950]; median arrival, May 12 (4); migration peak, May 15 to May 21; median departure, May 21 (7); latest departure, May 30, 1945. In fall, earliest arrival, August 19, 1942; median arrival, August 27 (5); migration peak, September 6 to September 25; median departure, September 28 (5); latest departure, October 10, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 2 (9/1-9/8); 13, 10 (9/9-9/18); 5, 1 (9/19-9/28); 0, 1 (9/29-10/7); 1, 0 (5/16-5/24); 0, 3 (5/25-5/30). The spring migration in 1943 was quite different from that of 1944 or 1945 (see indices). In the spring of 1943 nearly every day was spent in the field and the following numbers of Bay-breasted Warbers were recorded: May 8, 3; May 9, 3; May 12, 1; and May 20, 2. The largest number seen in one day in spring was 4 on May 25, 1945 [High 1950 spring counts: 15 on May 10, 19 on May 11, 24 on May 13, 16 on May 14.]; in fall, 22 on September 13, 1943.

*Black-poll Warbler, *Dendroica striata*.—Common (occasionally abundant) spring transient; common or uncommon (rarely abundant) fall transient. In spring, earliest arrival, April 25, 1948; median arrival, May 2 (7); migration peak, May 8 to May 27; median departure, May 30 (6); latest departure, June 7, 1945. In fall, earliest arrival, September 9, 1943 and 1944; median arrival, September 18 (4); migration peak, September 23 to October 5; median departure, October 16 (5); latest departure, October 26, 1947. In 1947, the fall migration was later than usual, the peak occurring between October 5 and October 17. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 2 (9/9-9/22); 15, 5 (9/23-10/1); 11, 13 (10/2-10/10); 4, 2 (10/11-10/16); 5, 5 (5/5-5/14); 12, 37 (5/15-5/25); 1, 16 (5/26-5/30); 0, 10 (5/31-6/6). The largest number seen in one day during the spring was 74 on May 16, 1945, and in fall, 140 on October 11, 1947.

*Pine Warbler, *Dendroica pinus*.—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, March 3, 1945; median arrival, March 14 (7); median departure, April 25 (4); latest departure, May 3, 1947. In fall, migration peak, September 6 to October 2; median departure, October 20 (5); latest departure, October 31, 1943. The bulk arrival of Pine Warblers in the spring usually occurred during the last half of March. This movement was apparently made up largely of resident birds, since they seemed to be well established on their territories before the advent of the migration peak which took place during the last half of April. The birds making up this peak movement were probably transients which nest farther north. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, + (7/27-8/11); 0, 1 (8/12-9/5); 8, 2 (9/6-9/14); 2, 3 (9/15-10/2); 3, + (10/3-10/13); +, 0 (10/14-10/26); +, + (3/5-4/18); 1, 2 (4/19-4/29); +, + (4/30-7/26). The lack of Pine Warblers during the period April 30 to July 26 in the seasonal population study was due to the absence of extensive stands of mature pine in the area censused. At this season Pine Warblers were restricted almost entirely to pine stands. The approximate Refuge nesting population in 1943 was 39 pairs.

*Prairie Warbler, *Dendroica discolor*.—Common spring transient and summer resident; uncommon fall transient. In spring, earliest arrival, April 16, 1944; median arrival, April 19 (9); migration peak, April 25 to May 16; latest departure, May 16, 1944 and 1945. In fall, earliest arrival, August 17, 1944; median departure, September 18 (6); latest departure, October 1, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 4 (7/27-8/26); 1, 3 (8/27-9/2); 1, 1 (9/3-9/13); 1, 4 (4/17-4/22); 12, 15 (4/23-6/27); 4, 7 (6/28-7/26). The highest number seen in one day in spring was 37 on May 3, 1947, and in fall, 7 on August 17, 1944. The approximate Refuge nesting population in 1943 was 151 pairs.

*Western Palm Warbler, *Dendroica palmarum palmarum*.—Uncommon or rare fall transient [Very rare spring transient.]. Earliest arrival, September 5, 1942; median arrival, September 27 (7); migration peak, September 23 to October 2; median departure, October 18 (5); latest departure, November 14, 1947. The frequency of occurrence of this form varied considerably from year to year. During some years it was regular in small numbers throughout the migration period, while in others it was seen only 2 or 3 times during the season. It usually occurred as singles or in twos or threes. The largest

number seen in one day was 8, recorded on September 23, 1943. Since this form migrates up the Mississippi valley in spring, it is not surprising that there are no spring records for the Refuge [One seen on May 10, 1950.].

*Yellow Palm Warbler, *Dendroica palmarum hypochrysea*.—Common spring transient; uncommon or rare fall transient. In spring, earliest arrival, March 30, 1945; median arrival, April 9 (7); migration peak, April 8 to April 25; median departure, May 2 (5); latest departure, May 6, 1943. In fall, earliest arrival, October 5, 1943; median arrival, October 9 (4); migration peak, October 12 to October 30; median departure, October 30 (6); latest departure, November 20, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 0 (10/5-10/11); 1, 1 (10/12-10/23); 5, 1 (10/24-10/30); 0, 7 (4/3-4/5); 0, 37 (4/6-4/9); 1, 3 (4/10-4/18); 63, 5 (4/19-4/24); 19, 0 (4/25-4/29); 1, 0 (4/30-5/2). Yellow Palm Warblers were usually found in flocks containing from 4 to 12 individuals. Largest number recorded in one day in spring was 63 on April 21, 1944; in fall, 15 on October 15, 1942. It is interesting to note that the fall migration period of this form was quite different from that of the Western Palm Warbler.

*Oven-bird, *Seiurus aurocapillus*.—Common summer resident and spring transient; uncommon fall transient. In spring, earliest arrival, April 19, 1945; median arrival, April 23 (7); migration peak, April 29 to May 9; latest departure, May 16, 1945. In fall, earliest arrival, August 28, 1943; median arrival, August 29 (3); migration peak, September 5 to September 28; median departure, October 8 (6); latest departure, October 19, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 1 (7/27-8/25); 6, 5 (8/26-9/28); 2, + (9/29-10/9); 4, 2 (4/21-4/29); 16, 12 (4/30-5/16); 10, 6 (5/17-6/20); 6, 1 (6/21-6/30); 1, 1 (7/1-7/26). Highest daily counts during spring and fall were 28 on May 7, 1943 [63 on May 6, 1950.] and 10 on September 16, 1943. The approximate Refuge nesting population in 1943 was 202 pairs.

*Northern Water-thrush, *Seiurus noveboracensis*.—Uncommon spring transient; rare fall transient. In spring, earliest arrival, April 25, 1944; median arrival, May 3 (6); migration peak, April 29 to May 22; median departure, May 25 (8); latest departure, May 30, 1946. In fall, earliest arrival, August 11, 1946; median arrival, August 19 (5); migration peak, August 28 to September 11; latest departure, October 10, 1947. The largest number observed in one day in spring was 16 on May 18, 1943; in fall, 5 on September 1, 1943.

*Louisiana Water-thrush, *Seiurus motacilla*.—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, March 28, 1944 and 1945; median arrival, April 6 (7); migration peak, April 17 to April 30; latest departure, May 8, 1943. In fall, earliest arrival, August 27, 1942; migration peak, August 29 to September 5; latest departure, September 8, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 1 (7/27-8/28); 4, 5 (8/29-9/5); 1, 0 (3/28-4/5); 1, 2 (4/6-4/16); 3, 4 (4/17-6/27); +, 2 (6/28-7/26). Highest numbers seen in one day in spring and fall were 6 on April 17, 1945, and 6 on September 1, 1943. The approximate Refuge nesting population in 1943 was 23 pairs.

*Kentucky Warbler, *Oporornis formosus*.—Common summer resident; uncommon spring transient; rare fall transient. In spring, earliest arrival, April 28, 1943; median arrival, May 1 (7). In fall, median departure, September 2 (6); latest departure, September 7, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 3 (7/27-8/21); 1, + (8/22-9/6); 4, 3 (5/3-5/8); 12, 16 (5/9-6/27); 9, 9 (6/28-7/26). Largest number seen on one day in spring was 23 on May 3, 1947 [39 on May 10, 1950.]; in fall, 4 on September 3, 1947. The approximate Refuge nesting population in 1943 was 188 pairs.

*Connecticut Warbler, *Oporornis agilis*.—Uncommon fall transient. Earliest arrival, September 9, 1943; median arrival, September 17 (5); migration peak, September 25 to October 9; median departure, October 13 (3); latest departure, October 29, 1947. Largest number observed on one day was 7 on October 3, 1947. Between 5 and 15

individuals were recorded each fall except 1947; that year, 37 birds were found as a result of more intensive coverage of appropriate habitats during the fall migration period. Since this species migrates up the Mississippi valley in spring, it is not surprising that there are no spring records for the Refuge.

*Mourning Warbler, *Oporornis philadelphia*.—Uncommon or rare spring transient; very rare fall transient. In spring, earliest arrival, May 23, 1944; median arrival, May 24 (3); median departure, May 31 (3); latest departure, June 11, 1945. Five birds on May 31, 1943, were the most recorded in one day. Single birds banded on September 11, 1943 [One seen on September 2, 1949.], and seen on October 7, 1947 and October 13, 1946, represent the only fall records.

*Yellow-throat, *Geothlypis trichas*.—Abundant spring transient and summer resident; common fall transient. In spring, earliest arrival, April 12, 1948; median arrival, April 20 (9); migration peak, April 30 to May 16; latest departure, May 22, 1945. In fall, earliest arrival, August 12, 1943; migration peak, September 1 to October 3; median departure, October 19 (6); latest departure, October 30, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 17, 21 (7/27-8/20); 11, 13 (8/21-9/22); 13, 2 (9/23-9/28); 4, 1 (9/29-10/13); 3, 6 (4/21-4/25); 16, 19 (4/26-4/29); 29, 32 (4/30-5/16); 20, 17 (5/17-6/29); 32, 24 (6/30-7/26). Highest number recorded in one day in spring was 78 on May 3, 1947 [105 on May 6, 1950.]. The approximate Refuge nesting population in 1943 was 397 pairs.

*Yellow-breasted Chat, *Icteria virens*.—Common spring transient and summer resident; uncommon fall transient. In spring, earliest arrival, April 30, 1946 [April 29, 1950]; median arrival, May 2 (9). In fall, earliest arrival, August 17, 1944; median departure, September 15 (7); latest departure, November 1, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 4, 5 (7/27-8/18); 1, 2 (8/19-9/13); 4, 1 (5/2-5/8); 11, 12 (5/9-6/29); 6, 8 (6/30-7/26). Highest numbers recorded in one day in spring and fall were 18 on May 12, 1945 [24 on May 6, 1950.], and 4 on August 25, 1944. The approximate Refuge nesting population in 1943 was 91 pairs.

*Hooded Warbler, *Wilsonia citrina*.—Common summer resident; uncommon spring and fall transient. In spring, earliest arrival, April 17, 1945; median arrival, April 25 (9); latest departure, May 27, 1944. In fall, earliest arrival, August 29, 1944; median departure, September 23 (7); latest departure, October 3, 1946. Seasonal population indices for the years 1943-44 and 1944-45 were: 9, 11 (7/27-9/9); 6, 5 (9/10-9/18); 2, 1 (9/19-9/23); 0, 3 (4/21-4/24); 10, 14 (4/25-4/30); 24, 21 (5/1-7/26). Largest number seen on one day in spring was 41 on May 3, 1947 [50 on May 6, 1950.]. The approximate Refuge nesting population in 1943 was 186 pairs.

*Wilson's Warbler, *Wilsonia pusilla*.—Uncommon spring transient; very rare fall transient. In spring, earliest arrival, May 9, 1943; median arrival, May 12 (5); migration peak, May 15 to May 20; median departure, May 24 (7); latest departure, May 31, 1943. In fall, earliest arrival, August 17, 1945; migration peak, August 25 to September 13; latest departure, September 23, 1943. Largest number observed on one day in spring was 9 on May 18, 1947. The 10 fall records were all of single birds.

*Canada Warbler, *Wilsonia canadensis*.—Common or uncommon spring and fall transient. In spring, earliest arrival, May 3, 1944 and 1947; median arrival, May 6 (6); migration peak, May 16 to May 24; median departure, May 27 (8); latest departure, June 4, 1945. In fall, earliest arrival, August 12, 1943, 1946, and 1947; median arrival, August 13 (7); migration peak, August 20 to September 1; median departure, September 19 (6); latest departure, October 12, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 1 (8/12-8/18); 30, 2 (8/19-8/25); 6, 3 (8/26-9/13); 0, 2 (9/14-9/22); 1, 0 (5/5-5/13); 7, 10 (5/14-5/18); 0, 3 (5/19-5/30). Highest daily counts in spring and fall were 35 on May 18, 1947 [72 on May 10, 1950.], and 33 on August 20, 1943.

*American Redstart, *Setophaga ruticilla*.—Common summer resident and spring and fall transient. In spring, earliest arrival, April 17, 1945; median arrival, April 20 (8); migration peak, May 3 to May 16; latest departure, May 23, 1944 and 1947. In

fall, earliest arrival, August 12, 1943; median arrival, August 16 (3); migration peak, August 26 to September 16; median departure, October 2 (5); latest departure, October 16, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 2 (7/27-8/8); 12, 2 (8/9-8/25); 20, 14 (8/26-9/16); 10, 5 (9/17-9/26); 7, 0 (9/27-10/2); 3, 2 (4/17-4/29); 8, 13 (4/30-5/13); 16, 32 (5/14-5/18); 9, 10 (5/19-6/16); 2, 4 (6/17-7/26). Highest daily counts in spring and fall were 42 on May 3, 1947 [91 on May 6, 1950.] and 36 on August 28, 1943. The approximate Refuge nesting population in 1943 was 225 pairs.

*English Sparrow, *Passer domesticus*.—Uncommon or rare permanent resident. The English Sparrow population generally ranged between 5 and 50 individuals. The variation was due in large part to irregular control of the birds by trapping and shooting, and to occasional influx of new flocks. During the greater part of the year English Sparrows commonly occurred in flocks of from 5 to 20 individuals. The breeding population in 1943 was 4 pairs, slightly less than usual. The winter survey totals were as follows: 1941-42, 17; 1943-44, 12; 1944-45, 12; 1945-46, 22; 1946-47, 23; 1947-48, 30 and 1948-49, 2. The actual winter populations in 1943-44 and 1944-45 were 12 and 19 individuals respectively.

*Bobolink, *Dolichonyx oryzivorus*.—Common fall transient; common or uncommon spring transient. In spring, earliest arrival, May 1, 1946; median arrival, May 3 (8); migration peak, May 7 to May 14; median departure, May 25 (6); latest departure, May 26, 1943 and 1945. In fall, earliest arrival, July 18, 1944; median arrival, August 15 (6); migration peak, August 25 to September 9; median departure, September 27 (5); latest departure, October 30, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 0 (8/20-8/24); 21, 76 (8/25-8/31); 23, 11 (9/1-9/10); 10, 0 (9/11-9/17); 1, 0 (9/18-9/23); 8, 1 (5/5-5/13). Largest number recorded in one day in spring was a flock of 110, seen on May 7, 1946. In fall, at least 200 were seen in one day in 1942. In spring, Bobolink flocks averaged about 15 individuals with a maximum of 110; the average fall flock contained 7 individuals, with a maximum of 45.

*Eastern Meadowlark, *Sturnella magna*.—Uncommon spring and fall transient; uncommon or rare winter resident; rare summer resident. In spring, earliest arrival, February 28, 1945; migration peak, March 27 to April 18; latest departure, April 29, 1944. In fall, earliest arrival, September 16, 1943; migration peak, October 17 to November 13. Flocks of meadowlarks larger than family groups were recorded from October 7 to April 18. The largest contained 32 individuals and remained on the Refuge during the winter of 1943-44. The breeding population of meadowlarks varied from 3 to 5 pairs. The wintering population was much more variable as is indicated by the following winter survey totals: 1941-42, 8; 1943-44, 28; 1944-45, 16; 1945-46, 1; 1946-47, 0; 1947-48, 2; and 1948-49, 1. The actual wintering populations during the winters of 1943-44 and 1944-45 were 32 and 14 individuals respectively.

*Red-wing, *Agelaius phoeniceus*.—Common (occasionally abundant) spring and fall transient; uncommon or rare summer resident; rare and irregular winter resident. In spring, earliest arrival, February 5, 1941; median arrival, February 21 (7); migration peak, February 24 to March 28; median departure, May 6 (6); latest departure, May 18, 1947. In fall, earliest arrival, September 15, 1942; median arrival, September 22 (3); migration peak, October 18 to November 16; median departure, November 25 (4); latest departure, December 15, 1944. The spring migration generally extended from the middle of February through the early part of May, with the peak usually occurring during the last week in February and in March. Flocks up to the middle of March were composed predominantly of adult males; those in late March, April, and early May were usually made up of females with a few first-year males. The start of the fall migration was difficult to determine since during the late summer Red-wings were found in flocks which seemed to wander unpredictably over the country-side. The main flight, however, usually occurred during the last half of October and the first half of November. Seasonal population indices for the years 1943-44 and 1944-45 were: 13, 1 (7/27-8/6); +, + (8/7-9/21); 1, 11 (9/22-10/8); 13, 5 (10/9-10/29); 30, 86 (10/30-11/16); +, 1 (11/17-2/9); 2, 2 (2/10-2/21); 95, 76 (2/22-3/10); 81, 6 (3/11-

4/3); 8, 8 (4/4-5/4); 1, 1 (5/5-7/17); 1, 6 (7/18-7/26). Red-wings commonly occurred in flocks except during the breeding season. In late summer these ranged in size from 6 to 40 individuals; in fall they averaged somewhat larger, ranging up to 150 individuals. Early spring flocks were sometimes quite large, with as many as 800 birds in a single group. The breeding population was low because of the small amount of appropriate habitat. Breeding pairs in 1943, 1944, and 1947 numbered 5, 5, and 8. Red-wings were usually either rare or absent in winter as indicated by the following winter survey totals: 1941-42, 0; 1943-44, 2; 1944-45, 1; 1945-46, 0; 1946-47, 0; 1947-1948, 51; and 1948-49, 1. One flock of 30 remained on the Refuge throughout the winter of 1943-44.

*Orchard Oriole, *Icterus spurius*.—Uncommon summer resident. In spring, earliest arrival, April 7, 1947; median arrival, April 30 (9). In fall, latest departure, September 1, 1944. The spring migration of transients was scarcely discernible due to the early arrival of the resident birds. Apparently the main part of the flight took place during late April and the first 10 days in May. The resident birds departed in the latter half of July; they were last recorded on July 29 in 1941; July 25 in 1944; July 18 in 1946; and July 19, in 1947. In some years (1942, 1943, 1944, 1948) transients were recorded between August 8 and September 1 (maximum 2 on August 11, 1943 and on August 29, 1944). The highest one-day count in spring was 6 on May 8, 1943. The Refuge breeding populations in 1943 and 1944 were 6 and 8 pairs respectively.

*Baltimore Oriole, *Icterus galbula*.—Uncommon spring and fall transient [Common in spring of 1950]. In spring, earliest arrival, April 26, 1948; median arrival, May 2 (7); migration peak, May 3 to May 12; median departure, May 19 (6); latest departure, June 12, 1946. In fall, earliest arrival, July 28, 1943; median arrival, August 8 (7); migration peak, August 18 to September 8; median departure, September 21 (7); latest departure, October 20, 1945. During the peak of migration in spring and fall it was not unusual to find from 3 to 5 Baltimore Orioles in one day. Largest number seen on one day in spring was 7 on May 11, 1945 [High 1950 spring counts: 18 on May 6, 40 on May 10, 30 on May 13.]; in fall, 11 on August 29, 1944. Baltimore Orioles were occasionally found in flocks of from 3 to 5 individuals. Although this species was not found on the Refuge as a summer resident it did occur as a regular breeding species on the Piedmont Plateau, less than 4 miles away.

*Rusty Blackbird, *Euphagus carolinus*.—Uncommon spring and fall transient; very rare winter resident. In spring, earliest arrival, February 25, 1949; median arrival, March 18 (7); migration peak, March 27 to April 13; median departure, April 26 (7); latest departure, May 10, 1946. In fall, earliest arrival, October 1, 1942; median arrival, October 20 (5); migration peak, October 23 to November 9; median departure, December 4 (4); latest departure, December 28, 1945. In spring, Rusty Blackbirds were usually found in small groups or flocks that contained from 2 or 3 to 40 individuals each. Fall flocks were sometimes larger, the largest recorded (165) being seen on October 25, 1944. A flock of 150 birds was seen on November 3, 1944. At the migration peaks it was usually possible to find 1 or 2 flocks during a day in the field. Small numbers remained on the Refuge throughout the winter of 1947-48, the largest flock recorded containing 18 birds.

*Grackle, *Quiscalus quiscula*. [*Purple Grackle. *Q. q. quiscula*, occurs throughout the year, except in late summer. *Bronzed Grackle. *Q. q. versicolor*, is a spring and fall transient and winter visitor; extreme dates, October 28 (1945) to December 22 (1944) and February 24 (1944) to April 6 (1947).] Abundant spring and fall transient; rare winter visitor; very rare late spring and early summer visitor (absent in late summer from July 1 to September 25). In spring, earliest arrival, January 28, 1944; median arrival, February 16 (7); migration peak, February 22 to March 28; median departure, March 31 (6); latest departure, April 14, 1944. In fall, earliest arrival, September 25, 1942; median arrival, October 4 (5); migration peak, October 26 to November 20; median departure, November 20 (7); latest departure, December 28, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 0 (7/27-9/27); 2, + (9/28-10/25); 102, 140 (10/26-11/17); 0, 1 (11/18-12/17); 0, 14,457 (12/18-12/24); 30, + (12/25-2/21); 191, 29 (2/22-3/22); 55, 2 (3/23-3/31); 3, 1 (4/1-5/16);

1, 1 (5/17-6/27); 0, 0 (6/28-7/26). In normal years the main flight in the fall occurred from the end of October to about the 20th of November with highest counts in the period November 2 to November 8 (in 5 out of 6 years from 1941 to 1946). In 1944, however, the migration was delayed by unseasonably warm temperatures. Although the first few migrants arrived on time that year, and over 2,500 birds were seen on November 8 and 9, no further flight materialized until December 16. From December 16 to December 21, 140,000 grackles were recorded, representing 97 percent of the fall flight. Eighty-three percent of the flight came on December 19-21, and 42 percent (60,000 individuals) on the peak day, December 20. A snowstorm ended the flight abruptly on the 22nd. The average size of the flocks during this flight was 2,212, whereas the average size during other years was only 286. In 1944, one flock of approximately 40,000 birds was recorded, while in other years the largest flock was 3,500.

During late December, January, and early February, grackles were of rare occurrence on the Refuge. Occasionally 1 or 2 birds lingered for 2 or 3 weeks following the migration period, and rarely small flocks visited the area. The spring flight generally came between the middle of February and the end of March, and occasionally small flocks remained through the first half of April. The migration peak was less pronounced and more variable in spring than in fall. The size of the flocks during the spring flight was found to average about 160 birds, with a maximum of 5,000. During early summer grackles occurred only as rare visitors, and usually these were seen as singles or pairs flying overhead. They did nest in nearby towns, however, the closest location being 1 mile from the Refuge. During migration, Purple Grackles and Bronzed Grackles commonly occurred together in mixed flocks. The proportions of the two subspecies at different seasons are indicated by the following totals of birds collected or banded: November 13 to 19—8 Bronzed, 6 Purples, 1 intermediate; December 18 to 27—42 Bronzed, 152 Purples, 17 intermediates; January 1 to 18—1 Purple, 1 intermediate; February 27 to 29—7 Bronzed, 3 Purples; March 4 to 21—74 Bronzed, 44 Purples, 5 intermediates.

*Cowbird, *Molothrus ater*.—Common spring and fall transient; rare summer resident; very rare winter visitor. In spring, earliest arrival, January 25, 1941; median arrival, February 17 (6); migration peak, March 9 to April 1; median departure, April 15 (4); latest departure, May 7, 1943. In fall, earliest arrival, September 23, 1942; median arrival, September 26 (4); migration peak, September 25 to October 30; median departure, December 3 (4); latest departure, December 23, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 0, 4 (7/27-8/21); 0, 0 (8/22-9/24); 29, 19 (9/25-10/31); +, 4 (11/1-12/20); +, 0 (12/21-3/7); 17, 9 (3/8-4/1); 4, 3 (4/2-5/2); 1, 3 (5/3-7/12); 4, 1 (7/13-7/26). During migration, Cowbirds commonly occurred in flocks. In fall these usually contained from 15 to 40 birds each with a maximum of 60 birds. Spring flocks averaged about 30 individuals each with a maximum of 100. Largest number recorded in one day in spring was 100 on March 9, 1945; in fall, 190 on October 5, 1943. The Refuge breeding population in 1943 was approximately 6 adults (3 males and 3 females). This is probably close to the usual population during most years. In 1947 and 1949, however, the population was probably about twice as high. Apparently most of these birds left the Refuge during late August and the greater part of September, as there were very few records for that period. Cowbirds were either absent, or rare and irregular during late December, January, and early February. On rare occasions 1 to 3 individuals were found on the Refuge for brief intervals.

*Scarlet Tanager, *Piranga olivacea*.—Common summer resident and spring transient [Abundant in spring of 1950.]; uncommon fall transient. In spring, earliest arrival, April 24, 1946; median arrival, April 28 (8); migration peak, May 2 to May 16; median departure, May 16 (3); latest departure, May 18, 1947. In fall, earliest arrival, August 17, 1945; migration peak, September 12 to September 28; median departure, October 4 (5); latest departure, October 10, 1947. Seasonal population indices for the years 1943-44 and 1944-45 were: 5, 8 (7/27-8/1); 2, 2 (8/2-8/22); 5, 2 (8/23-9/28); 1, 2 (9/29-10/7); 0, 6 (4/26-4/30); 12, 17 (5/1-5/16); 8, 7 (5/17-7/26). Highest number observed on one day in spring was 37 on May 18, 1947 [High 1950 spring counts: 68 on May 6, 94 on May 10, 110 on May 13.]; in fall, 11 on September 25, 1943. The approximate Refuge nesting population in 1943 was 215 pairs.

*Summer Tanager, *Piranga rubra*.—Very rare spring transient and summer resident. The earliest record of its occurrence in spring was on April 28, 1944. Birds believed to be migrants have been recorded from April 28 to May 5. Judging from their actions all birds observed after this date were summer residents. The latest record of this species was made on June 19, 1944. However, they undoubtedly remain on the Refuge much later than this. During most years 1 or 2 pairs remained on the Refuge to nest, and a very few individuals passed through the area in migration.

*Cardinal, *Richmondena cardinalis*.—Common permanent resident. Relatively little seasonal variation in the Cardinal population was apparent except for occasional slumps in winter which were probably due to adverse weather conditions or failure of food supply. The average number of Cardinals seen per trip in the seasonal population study in 1943-44 was 8.5 during the period September 5 to January 4, and 7.0 from January 5 to September 4. In 1944-45 this situation was largely reversed, the average number from September 5 to January 4 being 5.5 as compared with 12.4 for the period January 5 to September 4. Except during the nesting season, Cardinals were occasionally found in small, loose flocks of from 4 to 10 individuals. The largest, comprising 20 individuals, was recorded on November 12, 1944. The approximate Refuge nesting population in 1943 was 131 pairs. Wintering populations during 1943-44 and 1944-45 were approximately 59 and 141 individuals, respectively. This variation is not apparent in the winter survey totals, however, which are as follows: 1941-42, 53; 1943-44, 53; 1944-45, 61; 1945-46, 65; 1946-47, 50; 1947-48, 43; and 1948-49, 60 [1949-50, 89]. The discrepancy in relative abundance between winter population censuses and winter survey totals was probably due to a mid-winter influx of new birds during the winter of 1944-45. Since the winter surveys were taken in late December this change in population would not be indicated in their totals. Further evidence of such a change is furnished by monthly averages in the seasonal population study. These are as follows: winter, 1943-44—December, 5; January, 7; February, 6; and winter, 1944-45—December, 6; January, 12; February, 9.5.

*Rose-breasted Grosbeak, *Pheucticus ludovicianus*.—Uncommon spring and fall transient [Common in spring of 1950.]. In spring, earliest arrival, April 28, 1943; median arrival, May 3 (6); migration peak, May 6 to May 15; median departure, May 20 (7); latest departure, June 2, 1948. In fall, earliest arrival, September 8, 1943, and 1946; median arrival, September 9 (7); migration peak, September 17 to September 28; median departure, October 2 (5); latest departure, October 7, 1947. Largest number recorded in one day in spring was 18, on May 8, 1943 [High 1950 spring counts: 29 on May 10 and 31 on May 13.]; in fall, 5 on September 23, 1943.

*Blue Grosbeak, *Guiraca caerulea*.—Rare summer resident and spring and fall transient. The earliest record occurred on May 4, 1948, and the latest on October 3, 1947 and 1948. During the fall of 1947 one family was seen regularly through September 15; following this date 1 or 2 birds were occasionally seen through October 3. One to 3 pairs of Blue Grosbeaks usually remained on the Refuge to nest; a very few passed through the area during migration.

*Indigo Bunting, *Passerina cyanea*.—Common summer resident and fall transient; uncommon spring transient [Common in spring of 1950.]. In spring, earliest arrival, April 25, 1944; median arrival, May 3 (9); migration peak, May 16 to May 30; latest departure, May 30, 1944. In fall, earliest arrival, August 16, 1944; migration peak, September 9 to September 15; median departure, October 11 (6); latest departure, October 17, 1945. Seasonal population indices for the years 1943-44 and 1944-45 were: 9, 11 (7/27-8/9); 4, 8 (8/10-8/24); 5, 17 (8/25-9/29); 1, 2 (9/30-10/9); 5, 1 (4/30-5/7); 14, 15 (5/8-7/26). In late summer and fall Indigo Buntings commonly occurred in small groups or flocks of from 3 to 6 individuals. One flock containing 7 males and 1 female was recorded in spring on May 7, 1942. Highest number seen on one day in spring was 34 on May 18, 1947 [43 on May 13, 1950.]; in fall, 26 on August 29, 1944. The approximate Refuge nesting population in 1943 was 59 pairs.

Dickcissel, *Spiza americana*.—[Very rare spring transient. One observed on May 6, 1950.]

Evening Grosbeak, *Hesperiphona vespertina*.—Casual winter visitor [and spring visitor]. One bird was seen on December 8, 1945, during the greatest flight of Evening Grosbeaks recorded in Maryland. [Several records of from 1 to 8 birds were made during period, November 19, 1949 to January 22, 1950. One bird was seen on April 24, 1950.]

*Purple Finch, *Carpodacus purpureus*.—Common spring and fall transient; uncommon or rare winter resident. In spring, earliest arrival, March 11, 1943; median arrival, March 21 (7); migration peak, March 16 to April 29; median departure, May 5 (6); latest departure, May 17, 1949. In fall, earliest arrival, September 8, 1943; median arrival, September 29 (6); migration peak, October 18 to October 30; median departure, November 15 (4); latest departure, December 9, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 0 (9/9-10/3); 9, 0 (10/4-10/17); 44, 8 (10/18-10/31); 7, 8 (11/1-11/11); 2, 21 (11/12-11/25); +, 7 (11/26-3/9); 0, 38 (3/10-3/24); 0, 8 (3/25-4/13); 24, 1 (4/14-5/5). The migration periods and abundance of this species were extremely variable. Largest number seen on one day in spring was 100 on April 28, 1944; in fall, 78 on October 30, 1943. The Purple Finch commonly occurred in flocks, although occasionally singles or pairs were seen. Ordinarily, spring flocks were larger than those in fall or winter. At the height of the spring flight they averaged 19 birds each (largest 75), while those in fall and winter averaged 9 birds each (largest 23). Winter populations in 1943-44 and 1944-45 were approximately 5 and 39 individuals, respectively. Yearly variation is further indicated by the following winter survey totals: 1941-42, 10; 1943-44, 0; 1944-45, 23; 1945-46, 7; 1946-47, 7; 1947-48, 5; and 1948-49, 1 [1949-50, 70.].

Common Redpoll, *Acanthis flammea*.—Casual winter visitor. This species was heard calling while flying over the Refuge on January 19, 1947, during one of the largest flights into the northeastern United States in recent years.

Pine Siskin, *Spinus pinus*.—Irregular, rare, or uncommon spring and fall transient; very rare winter visitor. In spring, earliest arrival, March 5, 1944; median arrival, April 11 (5); median departure, April 27 (6); latest departure, May 7, 1942 [May 10, 1950]. In fall, earliest arrival, October 3, 1946; median arrival, October 22 (4); median departure, November 23 (3); latest departure, December 23, 1941. This species was entirely absent in some years and present in small numbers in others. During flight years it was generally more common in fall than in spring, and least common in winter. In the interval between the fall of 1941 and the spring of 1949 it was recorded in 6 out of 8 years, being absent in the fall, winter, and spring of 1942-43, and 1947-48. Pine Siskins often occurred in small flocks during the fall flight and were occasionally found in flocks in the spring as well, although records of singles were more numerous at that time. The largest fall flock (20 birds) was seen on November 8, 1946, while the largest in spring (19 birds) was recorded on April 22, 1946. Winter records were all either of single birds or pairs [flock of 55 observed on January 26, 1950.]. Some indication of the yearly variation in numbers is indicated by the following winter survey totals: 1941-42, 2; 1943-44, 0; 1944-45, 0; 1945-46, 2; 1946-47, 8; 1947-48, 0; and 1948-49, 0.

*American Goldfinch, *Spinus tristis*.—Common spring and fall transient; common or uncommon winter resident; uncommon summer resident. In spring, earliest arrival, March 20, 1945; migration peak, April 6 to May 5; latest departure, June 11, 1946. In fall, earliest arrival, September 23, 1943; median arrival, September 28 (3); migration peak, October 27 to November 16; latest departure, November 16, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 12, 14 (7/27-9/14); 28, 29 (9/15-10/24); 53, 54 (10/25-11/24); 12, 40 (11/25-1/14); 3, 36 (1/15-4/4); 23, 33 (4/5-4/24); 37, 11 (4/25-5/24); 14, 11 (5/25-7/26). Except during the summer goldfinches were generally found in flocks. These averaged 8 individuals in spring and fall, and 13 in winter. The largest flocks were seen in winter and spring: 115 on February 6, 1945, 100 on April 9, 1945, and 75 on April 16, 1944. The largest fall flock contained only 30 individuals. The highest number of individuals recorded on one day in spring was 100 on April 9, 1945 [166 on May 6, 1950.]; and in fall, 162 on November 9, 1944. In 1943 the Refuge breeding population was approximately 25 pairs.

Winter populations of goldfinches were found to vary considerably from year to year. In 1943-44 and 1944-45 the Refuge totals were approximately 193 and 536 individuals respectively. This yearly variation is further indicated by the following winter survey totals: 1941-42, 91; 1943-44, 120; 1944-45, 239; 1945-46, 98; 1946-47, 121; 1947-48, 9; and 1948-49, 92.

*Eastern Towhee, *Pipilo erythrophthalmus*.—Common summer resident and spring and fall transient; very rare (occasionally uncommon) winter resident. In spring, earliest arrival, March 14, 1943; median arrival, March 25 (5); migration peak, April 21 to May 12; latest departure, May 13, 1944. In fall, earliest arrival, October 1, 1944; migration peak, October 3 to October 30; median departure, October 30 (5); latest departure, November 5, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 9, 7 (7/27-10/1); 22, 25 (10/2-10/16); 16, 7 (10/17-10/31); 0, 5 (11/1-4/5); 1, 11 (4/6-4/18); 17, 14 (4/19-5/6); 9, 11 (5/7-7/26). The highest number recorded on one day in spring was 37 on May 3, 1947; in fall, 30 on October 9, 1943. Except during the breeding season, towhees frequently occurred in small groups or flocks ranging from 4 to 8 individuals. The largest, comprising 20 individuals, was noted on April 29, 1944. The approximate Refuge nesting population in 1943 was 150 pairs. In winter, towhees were either present in small numbers or absent entirely. The highest winter population occurred in 1944-45 when approximately 28 individuals were present. Yearly variation in wintering populations is indicated by the following winter survey totals: 1941-42, 11; 1943-44, 0; 1944-45, 26; 1945-46, 2; 1946-47, 0; 1947-48, 0; and 1948-49, 0. Towhees were entirely absent during 4 of the 7 past winters.

*Savannah Sparrow, *Passerculus sandwichensis*.—Uncommon spring and fall transient; very rare winter resident. In spring, earliest arrival, March 11, 1949; median arrival, March 21 (8); migration peak, March 28 to April 10; median departure, May 7 (7); latest departure, May 23, 1947. In fall, earliest arrival, September 13, 1945; median arrival, September 26 (5); migration peak, October 7 to October 30; median departure, October 30 (5); latest departure, November 1, 1947. The largest number seen on one day in spring was 20 on April 10, 1945; in fall, 9 on October 30, 1944. In spring Savannah Sparrows were sometimes found in small flocks containing up to 20 individuals, while in the fall, usually only singles or pairs were seen. This species was recorded in 4 winters. On January 16, 1944 1 was collected and during January and February, 1945, 3 were observed repeatedly. Three birds were also recorded on January 16, 1948, and 2 spent the following winter on the Refuge.

*Grasshopper Sparrow, *Ammodramus savannarum*.—Uncommon summer resident and spring and fall transient. In spring, earliest arrival, April 8, 1945; median arrival, April 22 (5). In fall, latest departure, October 27, 1943. An earlier spring record was made one-fourth mile from the Refuge on April 2, 1945, when one bird was seen. The only indication of a migration wave through the Refuge occurred on April 28, 1941, when from 15 to 20 birds were seen in one field. After mid-August this species became quite inconspicuous and was difficult to find. Small flocks of from 3 to 7 birds were sometimes seen in July, August, and early September. In 1943 the Refuge breeding population was 10 pairs; in other years it did not vary appreciably from this figure.

*Henslow's Sparrow, *Passerherbulus henslowii*.—Uncommon or rare summer resident; very rare spring and fall transient. In spring, earliest arrival, March 24, 1945; median arrival, April 16 (9). In fall, median departure, October 18 (3); latest departure, October 29, 1942. Because this sparrow requires for nesting, habitats represented in early recovery stages of abandoned field, numbers fluctuated as this transitory stage vanished after 3 to 5 years. Abandoned fields were extensive from 1936 to 1941 and at least 25 pairs nested each year. The number declined as the fields were invaded by dense growths of woody plants or were plowed. Breeding pairs in these years numbered as follows: 1942, 12, estimated; 1943, 2; 1944, 1; 1945, 0; 1946, 0; 1947, 4. Birds in 1947 nested in a field abandoned from farm use in 1945.

*Vesper Sparrow, *Pooecetes gramineus*.—Uncommon spring and fall transient; rare summer resident; very rare winter visitor. In spring, earliest arrival, March 5, 1945; median arrival, March 22 (7); migration peak, March 24 to April 20; latest departure,

April 26, 1945. In fall, earliest arrival, September 9, 1943; median arrival, September 14 (3); migration peak, September 28 to October 30; median departure, October 31 (5); latest departure, November 15, 1944. Largest number observed on one day in spring was 22 on March 28, 1944; in fall, 13 on October 30, 1943. Dates and number of birds in the largest flocks in migration were as follows: April 8, 1945 (10); April 3, 1945 (9); March 24, 1945 (7); October 28, 1945 (7). On the Refuge from 1942 to 1944 breeding pairs numbered 6, 5, and 4. Two records of single birds in winter were on January 18, 1947, and February 13, 1944.

*Lark Sparrow, *Chondestes grammacus*.—Casual late summer visitor. The first record in the Washington region since 1886 was an immature female, dead only a few hours, picked up inside the Refuge greenhouse on July 17, 1947.

Pine-woods Sparrow, *Aimophila aestivalis*.—Very rare summer resident. One singing male was located on the Refuge on May 13, 1945, and again on June 14, 1945, but apparently was absent during the intervening period, as the area was covered frequently without the bird being found. From June 14 to July 11 it was seen repeatedly and often heard singing, always at the same location. After this no more records of the species were made until June 16, 1947, when another singing male was located, this time in a different part of the Refuge. Pine-woods Sparrows were found nesting regularly on the Beltsville Research Center less than 3 miles from the Refuge.

*Slate-colored Junco, *Junco hyemalis*.—Abundant winter resident and spring and fall transient. In spring, earliest arrival, February 25, 1944; migration peak, March 22 to April 8; median departure, May 2 (6); latest departure, May 14, 1942 and 1943. In fall, earliest arrival, September 25, 1943; median arrival, September 29 (7); migration peak, October 23 to November 17; latest departure, December 5, 1944. The banding records show that the spring migration started in late February, although the total numbers present at one time were not appreciably increased until late March. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 2 (9/25-10/7); 39, 28 (10/8-10/19); 383, 225 (10/20-10/26); 1526, 438 (10/27-11/2); 317, 276 (11/3-11/19); 151, 224 (11/20-3/19); 335, 276 (3/20-3/25); 262, 55 (3/26-4/9); 84, 2 (4/10-4/30); 2, 0 (5/1-5/2). The highest number observed in one day in fall was 1,933 on October 27, 1943; in spring, 360 on March 25, 1944, and 361 on March 23, 1945. Juncos were found regularly in flocks during the entire period of their stay. These increased in size from an average of 9 birds per flock in late September and early October to 30 birds in late October and early November. The wintering flocks and migrating flocks in early spring averaged 18 birds. Later, as the population started to dwindle through April, the flocks became smaller, averaging 12 birds. The largest fall flocks contained 500, 475, 275, and 260 individuals, and were seen during the period October 26-October 30, 1943. Dates and numbers of the largest flocks in winter were: February 10, 1945 (150); January 17, 1944 (133); February 7, 1945 (127); and in spring, April 8, 1944 (250); February 28, 1945 (168); and March 4, 1944 (140). The wintering populations of Juncos showed considerable yearly variation as is indicated by the following winter survey totals: 1941-42, 676; 1943-44, 449; 1944-45, 1,283; 1945-46, 535; 1946-47, 561; 1947-48, 569; and 1948-49, 409. The actual Refuge wintering populations during 1943-44 and 1944-45 were found to be approximately 811 and 1,612 birds respectively.

*Tree Sparrow, *Spizella arborea*.—Common winter resident (no evidence of transients). Earliest arrival, November 6, 1943 and 1946; median arrival, November 7 (5); median departure, March 28 (6); latest departure, April 7, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 2, 1 (11/6-11/11); 12, 23 (11/12-11/29); 75, 41 (11/30-3/9); 28, 2 (3/10-3/18); 9, 0 (3/19-3/24); 1, 0 (3/25-4/7). Tree Sparrows usually occurred in flocks which were remarkably constant in size from season to season. The average of 115 flocks containing 4 or more birds was 15 individuals. The larger flocks sometimes ranged up to 70 or more individuals. The wintering populations of Tree Sparrows were found to vary considerably. This is shown by the following winter survey totals: 1941-42, 204; 1943-44, 151; 1944-45, 228; 1945-46, 337; 1946-47, 71; 1947-48, 177; and 1948-49, 124. The low figure in 1946-47 was

coincidental with a general slump in the wintering Tree Sparrow population throughout the Maryland Piedmont and Coastal Plain. The approximate Refuge wintering populations during 1943-44 and 1944-45 were found to be 381 and 705 birds respectively.

*Chipping Sparrow, *Spizella passerina*.—Common summer resident and spring and fall transient. In spring, earliest arrival, March 17, 1945 [March 8, 1950]; median arrival, March 25 (8); migration peak, April 9 to May 2; latest departure, May 4, 1945. In fall, earliest arrival, September 14, 1942 and 1945; median arrival, September 15 (4); migration peak, September 23 to October 5; median departure, November 9 (6); latest departure, November 29, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 29, 24 (7/27-9/13); 81, 58 (9/14-10/13); 33, 24 (10/14-11/3); 5, 15 (3/20-3/29); 11, 30 (3/30-4/8); 32, 32 (4/9-5/2); 24, 22 (5/3-7/26). The largest numbers recorded on one day in spring were 44 on April 9, 1945 and April 21, 1945 [51 on May 6, 1950.]; and in fall, 129 on September 28, 1943. Chipping Sparrows occurred regularly in flocks during the spring and fall migration and in late summer from the first of August on. The late summer flocks were small, usually ranging from 4 to 7 birds each, although one flock of 21 was seen as early as July 27, 1943. Fall flocks averaged 11 individuals each, with occasional flocks ranging up to 55 birds. Spring flocks averaged 5 individuals, with a maximum of 15 recorded on April 25, 1944. In 1943 the Refuge nesting population was approximately 55 pairs. The population during other years is not believed to have varied appreciably from this figure.

*Field Sparrow, *Spizella pusilla*.—Common summer resident and spring and fall transient; uncommon or rare winter resident. In spring, earliest arrival, March 8, 1944; migration peak, March 23 to April 29; latest departure, April 29, 1944. In fall, earliest arrival, October 2, 1944; migration peak, October 13 to October 30; latest departure, December 20, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 103, 57 (10/9-10/31); 14, 28 (11/1-12/20); 12, 10 (12/21-3/15); 24, 27 (3/16-10/8). The duration of the fall flight varied considerably, depending on the severity of weather conditions. Some years the migration extended past the middle of December, while in other years it was over by the middle of November. Field Sparrows were commonly observed in small flocks from early August until late April. These averaged between 6 and 7 individuals per flock except during the main part of the fall flight when they averaged about 13 individuals. Much larger flocks ranging up to 50 individuals were occasionally seen during the spring and fall migration peaks. The highest number of individuals recorded in one day in spring was 90 on March 23, 1945; and in fall, 232 on October 30, 1943. The breeding population of the Refuge in 1943 was approximately 145 pairs. The number of nesting birds varied from year to year, depending on the relative extent or area of brushy fields present. The wintering Field Sparrow population varied greatly from year to year, as indicated by the following winter survey totals: 1941-42, 3; 1943-44, 35; 1944-45, 57; 1945-46, 23; 1946-47, 15; 1947-48, 45; and 1948-49, 15 [1949-50, 75.]. The approximate winter populations during 1943-44 and 1944-45 were 43 and 76 individuals respectively.

*White-crowned Sparrow, *Zonotrichia leucophrys*.—Uncommon or rare fall transient; rare spring transient. In spring, earliest arrival, May 2, 1946; median arrival, May 3 (4); median departure, May 16 (7); latest departure, May 20, 1947. In fall, earliest arrival, October 2, 1943; median arrival, October 9 (5); migration peak, October 9 to October 23; median departure, November 11 (4); latest departure, December 4, 1944. In spring this species migrated through the Refuge in very small numbers, 3 being the most recorded in any one day. In fall it was not unusual to record 4 or 5 during a day (maximum 12 on October 9, 1943).

*White-throated Sparrow, *Zonotrichia albicollis*.—Abundant spring and fall transient; common or uncommon winter resident. In spring, earliest arrival, March 16, 1945; migration peak, April 21 to April 30; median departure, May 27 (6); latest departure, June 10, 1946. In fall, earliest arrival, September 20, 1943 and 1944; median arrival, September 23 (6); migration peak, October 12 to October 30; latest departure, December 20, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 10, 5

(9/23-9/30); 95, 95 (10/1-10/31); 5, 81 (11/1-12/20); 1, 38 (12/21-3/15); 1, 17 (3/16-4/13); 123, 76 (4/14-5/1); 17, 18 (5/2-5/12); 6, 0 (5/13-5/16). The highest number seen on one day in spring was 336 on April 29, 1944; and in fall, 196 on October 30, 1943. White-throated Sparrows commonly occurred in flocks which generally averaged between 6 and 11 birds each, with the larger ones during migration ranging up to 50 individuals. In late spring the flocks gradually became smaller in size until only a few singles were left; these sometimes lingered for 2 or more weeks after the bulk of the birds had departed. Singles were recorded in June on two occasions, June 4, 1945, and June 10, 1946. The Refuge wintering population of White-throated Sparrows varied considerably from year to year as is indicated by the following winter survey totals: 1941-42, 84; 1943-44, 11; 1944-45, 233; 1945-46, 111; 1946-47, 160; 1947-48, 90; and 1948-49, 64. The actual wintering populations during 1943-44 and 1944-45 were approximately 34 and 456 individuals respectively.

*Fox Sparrow, *Passerella iliaca*.—Common spring transient; uncommon fall transient; very rare winter resident. In spring, earliest arrival, February 4, 1944; median arrival, February 15 (6); migration peak, February 28 to March 25; median date of departure, April 8 (5); latest departure, April 10, 1945 [April 28, 1950]. In fall, earliest arrival, October 8, 1943; median arrival, October 19 (7); migration peak, November 9 to November 17; median departure, November 23 (3); latest departure, November 29, 1944. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, 3 (10/23-11/7); 4, 14 (11/8-11/19); 3, 4 (11/20-11/29); 0, 0 (11/30-2/3); 1, 0 (2/4-2/18); 4, 23 (2/19-2/27); 24, 75 (2/28-3/16); 67, 1 (3/17-3/26); 3, 0 (3/27-4/1). Migration periods and populations of migrating Fox Sparrows varied considerably from year to year as did the size of individual flocks. Fall flocks were quite small, the largest recorded containing only 8 individuals. Spring flocks averaged 8 birds each, with the larger flocks ranging up to 68 individuals. The largest number of individuals observed on one day in spring was 145 on March 22, 1944; in fall, 17 on November 9, 1944. Wintering Fox Sparrow populations were always very sparse, if present at all. This is indicated by the following totals of winter surveys: 1941-42, 10; 1943-44, 0; 1944-45, 4; 1945-46, 1; 1946-47, 3; 1947-48, 0; and 1948-49, 0.

*Lincoln's Sparrow, *Melospiza lincolnii*.—Rare fall transient; very rare spring transient. In spring, earliest arrival, May 3, 1947; latest departure, May 20, 1944. In fall, earliest arrival, September 12, 1943; median arrival, October 3 (4); migration peak, October 4 to October 12; median departure, October 12 (4); latest departure, October 30, 1943. The general scarcity of Lincoln's Sparrows on the Refuge is shown by the fact that only 21 records were made in fall and only 8 in spring. However, this scarcity of records was undoubtedly due in part to the inconspicuousness of the species, since nearly half of the records were of birds captured in banding traps. Observations in spring were of single birds except on May 18, 1949, when 2 were recorded. The highest number seen in one day in fall was 3 on October 4, 1947.

*Swamp Sparrow, *Melospiza georgiana*.—Common or abundant fall transient; common spring transient; rare or uncommon winter resident. In spring, earliest arrival, March 16, 1944; median arrival, March 20 (3); migration peak, April 17 to May 2; median departure, May 21 (6); latest departure, May 26, 1945. In fall, earliest arrival, September 18, 1943; median arrival, September 24 (6); migration peak, October 2 to October 27; median departure, November 9 (3); latest departure, November 30, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 3, 2 (9/25-9/30); 2, 15 (10/1-10/7); 26, 14 (10/8-10/28); 3, 7 (10/29-11/9); 1, + (11/10-12/5); 0, 0 (12/6-3/18); 0, 6 (3/19-4/5); +, 6 (4/6-4/16); 15, 9 (4/17-5/3); +, 5 (5/4-5/13); 0, 1 (5/14-5/25). There are a few local swales on the Refuge where Swamp Sparrows are very numerous during migration, and where the few wintering birds remain. The largest number seen at one time was about 100 individuals recorded on October 12, 1946, all within a 2½-acre plot. The highest number seen in one day in spring was 38 on April 29, 1944. Small numbers of Swamp Sparrows wintered on the Refuge each year. The approximate numbers present in 1943-44 and 1944-45 were 11 and 22 individuals respectively. Yearly variation in wintering populations is

further indicated by the following winter survey totals: 1941-42, 4; 1943-44, 9; 1944-45, 16; 1945-46, 12; 1946-47, 12; 1947-48, 44; and 1948-49, 8. The absence of Swamp Sparrows in winter in the seasonal population indices was due to the relatively small amount of suitable habitat present in the study area that these figures were derived from.

*Song Sparrow, *Melospiza melodia*.—Abundant spring and fall transient; common or uncommon winter resident; rare summer resident. In spring, earliest arrival, February 19, 1945; median arrival, February 22 (4); migration peak, March 4 to March 25; latest departure, April 29, 1944. In fall, earliest arrival, September 20, 1943; median arrival, September 30 (5); migration peak, October 13 to October 30; latest departure, November 19, 1943. Seasonal population indices for the years 1943-44 and 1944-45 were: 1, + (9/13-9/30); 5, 13 (10/1-10/8); 46, 24 (10/9-10/31); 8, 18 (11/1-11/19); 2, 12 (11/20-2/20); 29, 17 (2/21-3/4); 128, 84 (3/5-3/25); 32, 12 (3/26-4/1); 14, 1 (4/2-4/9); 3, 1 (4/10-4/29); +, + (4/30-9/12). The highest number recorded on one day in spring was 200 on March 4, 1945; and in fall, 127 on October 27, 1943. The Refuge breeding population was always small. The total populations in 1943 and 1944 were 9 and 6 pairs respectively. In 1948 and 1949 at least 12 pairs were present. The winter populations varied considerably from year to year. This is shown by the following Refuge winter survey totals: 1941-42, 53; 1943-44, 35; 1944-45, 91; 1945-46, 82; 1946-47, 66; 1947-48, 86; and 1948-49, 23. The approximate Refuge winter populations in 1943-44 and 1944-45 were 63 and 114 individuals respectively.

Summary

A detailed study of seasonal changes in bird populations was made at the Patuxent Research Refuge, located between Bowie and Laurel, Maryland, during the years 1936-1949. The history of the Refuge is reviewed and its physical and biological characteristics summarized.

The methods of study used during the investigation included: periodic censuses of a representative 304-acre study area over a two-year period; a census of the breeding population of the entire Refuge during one year; detailed population studies of representative habitats during the breeding season; censuses of the wintering population of the entire Refuge during two years; general surveys of wintering populations for seven years; and general observations of seasonal changes in bird populations over a fourteen-year period, including data from an extensive banding program and from many special types of censuses.

The phenology of the Refuge is described in considerable detail throughout the year, with special attention given to major fluctuations in bird populations as correlated with climatic changes and with seasonal aspection of the vegetation. The component species of birds in the more important migration waves are listed. Figures approximating the Refuge breeding and wintering populations are given, while indices representing the relative abundance of bird populations, based on figures from the two-year seasonal population study, were obtained for the entire year.

The greatest variety of species as well as the greatest number of individuals occurred on the Refuge during the migration periods in spring and fall, the variety of species being slightly higher in spring than in fall, while the population of individuals was considerably higher in fall. Wintering and breeding populations were low and relatively stable compared to the populations at other seasons.

The ecological affinities of the bird populations differed greatly from one

season to another. Species characteristic of edge habitats were much more numerous in winter, while forest species were predominant in summer. Insectivorous species comprised a large proportion (40 to 60 percent) of the total population during the warmer months, but were of minor importance in winter. The greatest number of species of birds on the Refuge occurred during the population peaks of insectivorous species, while the largest number of individuals was found during the population peaks of omnivorous and herbivorous species. The population peaks of insectivorous species were found to occur much later in spring and considerably earlier in fall than the corresponding peaks of omnivorous and herbivorous species. The *Fringillidae* contributed the greatest number of individuals in winter, while the *Parulidae* was the most important family (numerically) in summer. Water birds and marsh birds were relatively unimportant throughout the year, due to the scarcity of suitable habitats.

Permanent resident species were found to vary from about one-fifth to slightly less than one-half of the total population throughout the year, although many individuals of these species were either transients or part-time residents. Summer residents and winter residents were more abundant than permanent residents during their respective periods of occurrence. During the greater part of the migration period, transient species were found to comprise only 10 to 20 percent of the total population. However, transient individuals of all species would account for a much larger proportion of the population at this time.

After comparing the results of these investigations with similar studies in other areas, it is believed that the seasonal population changes on the Patuxent Research Refuge are fairly representative of those occurring throughout the Middle Atlantic and East-central States.

Yearly variations in seasonal population changes are described and the causative factors indicated, when known. Of these, food supply and weather conditions were generally the most important.

The data from the seasonal population studies on the Refuge support certain conclusions made by Kendeigh (1934) regarding the migratory movements of birds. These are: "The regulation of migration as to time is controlled in the spring by rising daily maximum and night temperatures and changing relative proportions daily of light and darkness. In the autumn, decreasing temperatures, particularly at night, longer nights and shorter days, and for some species, decreasing food supply, are most important."

The seasonal distribution of the population of each of the 229 species of birds that have been recorded on the Refuge is described in detail. This includes data on migration periods such as earliest dates of arrival, latest dates of departure, median dates of arrival and departure, and migration peaks. Population indices are also listed for many of the more common species throughout their periods of occurrence, and the numerical status of wintering and breeding populations is indicated as well. In many cases, the highest numbers of individuals observed in one day during the migration periods are given and the size of flocks at different seasons described.

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SPECIES INDEX

The Bimodality of Length Distribution in Heterodon p. platyrhinos L. and its Relation to the Season in Which the Specimens Were Collected*

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During the course of this investigation, two separate series of *Heterodon p. platyrhinos* L. were studied. The first (AIO) series included a total of 441 specimens distributed throughout the geographic range of this form, while the second (K) series included a total of 89 specimens. Body length in the AIO series was defined as the number of centimeters from the anterior end of the head to the posterior border of the last ventral scale.

Figure 1 illustrates the frequency distribution of body lengths in the AIO series; the polygon clearly suggests a bimodal distribution. It is evident that the bimodality cannot be attributed to sexual dimorphism, for when the length distributions of the 220 females and the 221 males are plotted separately, the bimodality remains apparent.

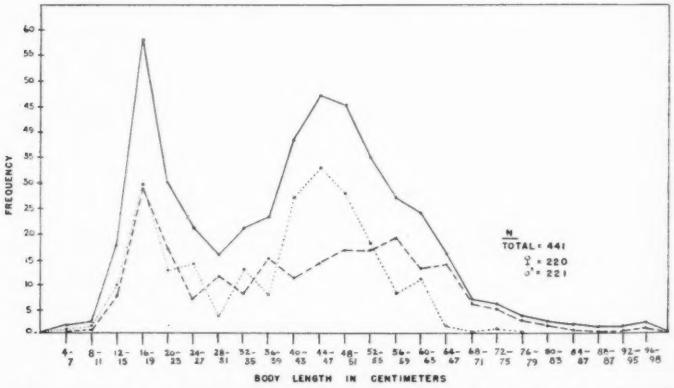


Fig. 1.—Frequency polygon illustrating the distribution of body length in the entire sample of the AIO series of *Heterodon p. platyrhinos* L.
Legend: – – – Females; . . . Males; —— Both Sexes.

*Based on material included in a thesis submitted by the senior author (Now Mrs. Herbert Marer) in partial fulfillment of the requirements for the degree of Master of Science at the University of Oklahoma, Norman. The authors wish to express appreciation to Dr. A. I. Ortenburger for permission to use specimens from the collection of the Museum of Zoology, University of Oklahoma, for the loan of individual data on the AIO series, and for many helpful suggestions; and to Dr. Richard Blanc and Dr. A. O. Weese for their numerous helpful suggestions and their constant interest and encouragement.

Since this sample was collected throughout the entire geographic range of *Heterodon p. platyrhinos*, the bimodality could be attributable to geographic variation if there were any marked tendency for collections to be concentrated in specific localities within the geographic areas from which they were obtained. But there is no evidence to suggest any such tendency, and, in fact, the bimodality is also evident in material collected within any one of the individual regions represented in the sample by a sufficient number of specimens to justify plotting a frequency distribution. Figure 2 shows the body length distributions of the specimens from each of the areas from which at least 45 snakes were obtained; the polygons consistently show bimodal tendencies.

A reasonable explanation of the bimodal distribution of body length in *H. p. platyrhinos*, suggested to the authors by Dr. Richard Blanc, is based on the fact that snakes are collected predominantly in the spring and summer months. The largest number of specimens is collected during spring and summer, fewer specimens are collected in the fall, and a negligible number is collected during the winter. In the present material, information on the season of collection was available for 139 specimens. Of these, 104 (75%) were collected during the spring and summer, while only 27 (19%) were collected in the fall and 8 (6%) in the winter. It is manifest from these data that there is seasonal discontinuity in the collection of material.

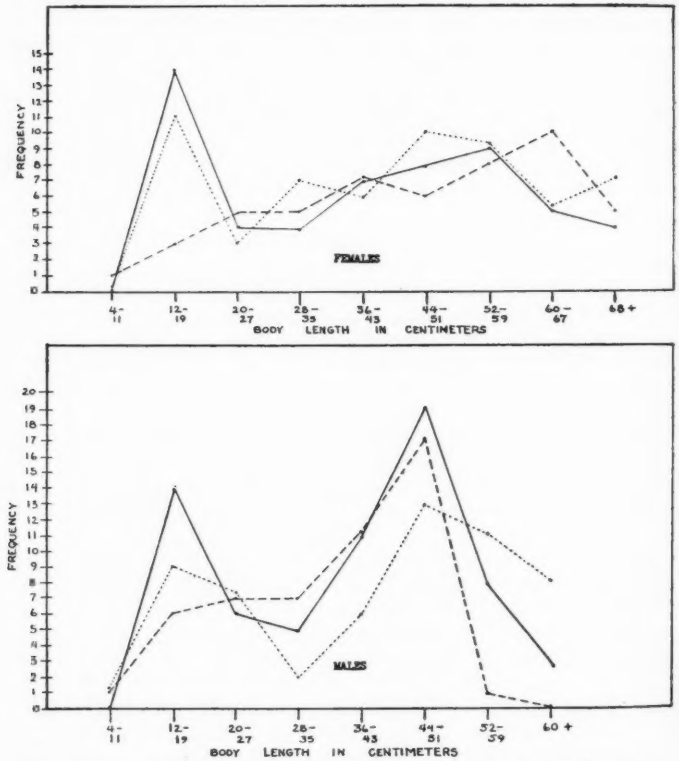
If snakes continue to grow in length during the winter months sufficiently to pass from one size group to the other or if there is an excessively high mortality of newly hatched snakes during their first winter months, it would be expected that specimens in the smallest size range would be poorly represented in spring and early summer collections. The smallest specimens should increase in relative frequency during the late summer and should reach their maximal proportionate representation in samples collected during the fall and early winter months.

It may be presumed that the rate of growth is rapid during the first year of life and then tends to level off. As a consequence, snakes collected in their second summer should be considerably longer than those collected in their first summer, while the distribution of body lengths for specimens more than two years of age should not reveal any appreciable discontinuities. This is essentially the case with the rattlesnakes (Klauber, 1937); the young grow rapidly, and there is a subsequent decrease in the growth rate, with a corresponding difficulty in the segregation of adolescents from adults.

In order to test the hypothesis just outlined, the entire sample was divided into three length groups: group A, specimens shorter than 21.5 cm.; group I, specimens from 21.5 through 35.9 cm.; and group B, specimens 36.0 cm. or longer. Since the distribution is continuous, such a division must be more or less arbitrary. The group limits were chosen in the hope that group A would be composed predominantly of snakes from the presumed population in which body length clusters about a modal value of 16 to 19 cm., by hypothesis, the younger snakes, perhaps those in their first season of growth. Group B should represent a population in which the modal body length lies between 44 and

47 cm.; these snakes should be adults of varying ages. It should be emphasized that the intermediate group (I) is not presumed to represent specimens intermediate in age between those found in groups A and B; it is a composite group representing the upper and lower tails, respectively, of the A and B distributions.

In *H. p. platyrhinos*, the young generally are assumed to hatch during the period extending from July through September. On our hypothesis, group A is composed predominantly of snakes collected in the year during which they were hatched, while group B is composed of "adult" snakes collected one or more years after hatching. If the hypothesis is tenable, samples collected prior to, or in the early part of, the hatching season should consist preponderantly



Legend: —— North Atlantic; – – – South Atlantic; . . . North East Central.

Fig. 2.—Frequency curves illustrating the distribution of body length in samples of the AIO series of *H. p. platyrhinos* collected from the North Atlantic, South Atlantic and North East Central geographic areas.

of group B specimens, while the fall and winter collections should consist predominantly of individuals from group A. Both Figure 3 and Table 1 indicate that this is the case.

Figure 3 is a frequency polygon contrasting the distribution of "juveniles" and "adults" in samples collected during the spring and summer months with the distribution of these same groups in samples collected during the fall and winter months. The polygon clearly indicates that "juveniles" comprise the greater portion of the fall and winter collections, while most of the specimens collected in the spring and summer belong in the "adult" group.

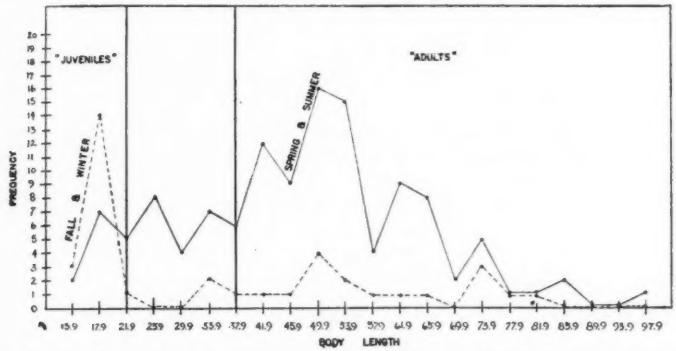


Fig. 3.—Frequency polygons illustrating the distribution of body length in samples collected during the spring and summer and in samples collected during the fall and winter.

Table 1 shows the available data for season of collection for groups A and B respectively.

By combining spring and summer collections on the one hand and the fall and winter collections on the other, a fourfold table may be formed and a chi-square test used to test the significance of the seasonal differences of the proportionate frequencies of group A and group B specimens (see Table 2).

TABLE 1.—Distribution of body length—grouped according to the season in which the specimens were collected

		Number of specimens collected during:			
		Spring	Summer	Fall	Winter
Females					
	Group A	3	6	14	0
	Group B	18	32	8	5
Males					
	Group A	3	2	4	0
	Group B	12	28	1	3
Both Sexes					
	Group A	6	8	18	0
	Group B	30	60	9	8

TABLE 2.—Seasonal differences between frequencies of Group A and Group B specimens

		Spring & Summer Collections	Fall & Winter Collections	
Females				
	Group A	9	14	$X^2 = 10.9$*
	Group B	50	13	$P = 0.001$
Males				
	Group A	5	4	$X^2 = 4.8$*
	Group B	40	4	$P = 0.03$
Both Sexes				
	Group A	14	18	$X^2 = 21.3$
	Group B	90	17	$P = 0.00004$

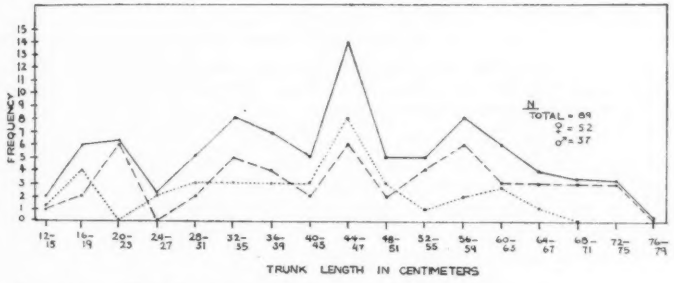
* Corrected for continuity.

The chi-square values for the females alone ($N = 86$, $P = 0.001$) and for both sexes combined ($N = 139$, $P = 0.00004$) are highly significant, while the chi-square for the males ($N = 53$, $P = 0.03$) is of borderline significance. The reality of the seasonal differences in the proportions of group A and group B specimens may be regarded as statistically established. The direction of these differences is consonant with the proposed hypothesis that groups A and B represent specimens of different ages.

Confirmatory evidence to support this hypothesis can be derived from the K-series of *H. p. platyrhinos*. This series consists of a total of 89 specimens (52 females and 37 males) collected almost entirely within the state of Oklahoma. In the K-series, trunk length (the number of centimeters from the anterior border of the first ventral scale to the posterior border of the last ventral scale) was considered instead of body length. It is obvious, however, that this difference in the type of measurement should not affect the validity of the ensuing comparisons.

Figure 4 is a frequency polygon illustrating the distribution of trunk length in the entire sample of the K-series (compare with Figure 1). The multimodality of the distribution is evident in both sexes, and therefore cannot be attributed to sexual dimorphism. Consultation of the frequency distribution shows that it appears to reflect the bimodality that was conspicuous in the AIO series, in this case masked by the small size of the sample. It is more difficult here to delimit a "juvenile" and an "adult" group with any degree of assurance that each will contain a minimum number of individuals belonging to the other group. For this reason, a division into two groups was made on the basis of the more evident cleavage found in the length distribution of the larger AIO series. Allowance was made for the fact that the head was included in the length measurements of that series but not in the present measurement. The sample was divided into two portions: group A, those specimens with trunk lengths less than 32.0 cm. and believed to correspond predominantly to the "juvenile" group of the AIO series; and group B, those specimens with trunk lengths of 32.0 cm. or more, believed to correspond mainly to the "adult" group of the AIO series.

It was argued from the data on the AIO series that the bimodal distribution of body length reflected the existence of two age groups in the sample. Support for this view was found in the fact that the ratio of group A to group B specimens was significantly smaller for snakes of that series which were collected in spring and summer than it was for those specimens collected in fall and winter (see Table 2). The summarized figures for the distribution of trunk length according to the season of collection of the specimens of the K-series are shown in Table 3.



Legend: —— Both Sexes; – – – Females; . . . Males.

Fig. 4.—Frequency polygon illustrating the distribution of trunk length in the entire sample of the K-series of *H. p. platyrhinos*.

TABLE 3.—Distribution of trunk length—Grouped according to the season in which the specimens were collected

		Number of specimens collected during:	
		Spring & Summer	Fall & Winter
Females			
	Group A	5	1
	Group B	29	2
Males			
	Group A	6	1
	Group B	19	2
Both Sexes			
	Group A	11	2
	Group B	48	4

In each case the number of snakes collected in fall and winter is too small to permit distinguishing the ratio of group A : group B specimens collected in these seasons from the ratio of group A : B specimens collected in the spring and summer, as was done for the AIO series (see Table 2). But when both sexes are combined, the A to B ratio among the spring and summer collections in the K-series may be compared with both the A to B ratio among spring and summer collections and the A to B ratio among the fall and winter collections of the AIO series (see Tables 4 and 5).

TABLE 4.—Comparison of number of Group A and Group B specimens, respectively, among spring & summer collections in the K-series with those among spring & summer collections in the AIO Series, both sexes combined.

	Number of specimens collected during spring & summer:	
	K-Series	AIO Series
Group A	11	14
Group B	48	90
	Chi-square = 0.78	
	P = 0.38	

TABLE 5.—Comparison of number of Group A and Group B specimens, respectively, among spring & summer collections in the K-Series with those among fall & winter collections in the AIO Series, both sexes combined.

	K-series	AIO Series
	Number of specimens collected during:	
	Spring & Summer	Fall & Winter
Group A	11	18
Group B	48	17
	Chi-square = 11.07	
	P = 0.0009	

Table 4 shows that the A:B ratio among the spring and summer collections in the K-series is not significantly different from the A:B ratio among spring and summer collections of the AIO series (chi-square = 0.78, P = 0.38). On the other hand, Table 5 clearly indicates that the A to B ratio among specimens collected in the spring and summer in the K-series differs significantly from the A to B ratio among specimens of the AIO series collected in the fall and winter (chi-square = 11.07, P = 0.0009).

Therefore, it seems justifiable to suspect that the same factors which were provisionally accepted as the cause of the bimodality of length distribution in the AIO series are also operative in the K-series and that groups A and B of the K-series also represent two age groups. It should be emphasized, however, that it would not be possible to formulate this hypothesis solely upon the limited data available for the K-series—it rests primarily upon the analysis of the more extensive material in the AIO series.

DISCUSSION

Specimens of *H. p. platyrhinos* from museum collections exhibit a bimodality in length distribution that cannot be attributed to either sexual dimorphism or geograpric heterogeneity; the only readily apparent explanation of the bimodality is that the material represents two age groups. Differences between the relative frequencies of smaller and larger specimens collected in the spring and summer and the fall and winter, respectively, were shown to be statistically significant and consonant with the hypothesis that there are two age groups in the sample.

The bimodality of length distribution found in these samples of *Heterodon*

p. platyrhinos is of the same nature as that found by Klauber (1937) in a territorially homogeneous sample of *Crotalus v. viridis*. The juveniles in his material were set off from the adolescents and the adults, with age discrimination made not only on the basis of the distribution curve, but also on such criteria as the number of rattles in unbroken rattle strings and the percentage of gravid females. The evidence from the rattlesnakes tends to substantiate the inferences that have been drawn from the data on *Hetrodon p. platyrhinos*.

It was indicated that the observed discontinuity in length might be interpreted, according to this hypothesis, on either of two assumptions: (1) snakes grow appreciably in length during the winter months, or (2) young snakes in their first year have an excessively high mortality rate.

Collateral evidence from other species does not support the assumption of appreciable growth during the winter. In general, the growth rate of poikilothermous animals is depressed at lower temperatures. Klauber (1937) found that both juvenile and adult specimens of *Crotalus v. viridis* failed to increase appreciably in length during their period of hibernation, i.e., during the fall and winter months. Therefore, it would seem unlikely that the increased proportion of specimens in the larger length classes found among collections made in the spring can be explained by the assumption that the snakes were hatched during the previous year and grew into the adult class during the winter.

On the other hand, there is a considerable body of evidence from many species that indicates that a peak in the mortality rate during very early life is a rather general phenomenon. In snakes, juveniles are often more variable than adults of the same species; this has been attributed to the elimination of extreme variants in early life. Klauber (1936), in studying *Crotalus v. viridis*, concluded that there was a high mortality rate among juveniles, attributable not only to the elimination of aberrant specimens, but also to the fact that the young are "more careless of concealment" and are preyed upon by more animals than are the adults. He also suggested that selective losses were less important among the young in the spring months than they were in the autumn. His conclusions are consistent with the indications from these data.

SUMMARY

The bimodality of length of distribution in two samples of *Heterodon p. platyrhinos* herein investigated appears to be attributable to the existence of two age groups, a peak in fall and winter determined by the young of the year, and that during spring and summer by individuals in their second and later years. An additional hypothesis that the relative deficiency of small specimens among samples collected in spring and early summer is a consequence of the selective elimination of young snakes during fall and winter appears plausible on the basis of collateral evidence.

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———1937—A statistical study of the rattlensakes, IV—the growth of the rattlesnake. Ibid. 3: 1-56.

Some Observations on Pseudacris nigrita triseriata (Wied) in Texas

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The observations herein presented are based on studies carried out primarily in the vicinity of Huntsville, Walker County, Texas, from November, 1946 through May, 1949. Because of existing conditions and available time, the most consistent season of observations was conducted in 1949 with emphasis being placed upon the activities of that year. Huntsville is located in a transitional area between the humid, mixed pine-hardwoods of the east and the drier, oak-prairies to the west. Such an area provides abundant varied habitats and breeding sites for amphibians.

Breeding Activities

Appearance at breeding sites.—The appearance of *Pseudacris n. triseriata* in breeding congresses may occur at unexpected times in Texas. During the winter of 1946-47 the form was in small temporary ponds in Sam Houston Memorial Park, Huntsville, Walker County, and laying eggs by December 5-6. Undoubtedly the first appearance at these sites was somewhat earlier, around November 18-21, for on the twelfth and fifteenth of December tadpoles were collected that were about ¾" in length. Following this small initial appearance, there was little activity until January 10-20, which represented the peak of egg laying for the year. The earliest appearance of *P. n. triseriata* in Texas is similar to that of *P. ornata* as reported by Harper (1937) in Georgia. At other localities in Walker County newly deposited egg masses were noted on February 22 and March 8 and 14; however these were present as only two to four packets in each pond. In 1948 breeding pairs were observed only on April 25 in spite of efforts to locate breeding populations at other dates. January 8 was the earliest date of appearance during 1949, but egg laying was delayed until February 4-5 by a sudden drop in temperature resulting in a seven-inch snowfall January 29-30, which remained on the ground for four days. Following a rise in temperature and warm rains intense egg deposition took place between February 7 and 11 with a lesser period extending from February 20-24 and isolated cases on March 11, 21, April 3, 5 and 20.

The irregular manner of egg deposition led to an examination of the weather data for the vicinity in an effort to determine, if possible, what physical factors might be instrumental in initiating the egg deposition periods. Daily weather data from Huntsville were obtained from the United States Weather Bureau publication, Climatological Data. Maximum and minimum temperatures and precipitation were plotted and known egg laying dates entered on the graphs for the months of January through May of 1949. Sim-

ilar data were plotted for November and December of 1946, but are not used here, for field data with which to compare are deemed too meager. In general the results show that there appears to be some correlation between these climatic data and egg deposition, in the following sequence: a drop in temperature, a subsequent rise in temperature with accompanying precipitation, and then egg laying during the rise in temperature, but usually after the rain. The data are based on the eight separate periods of egg laying during the months of February, March, and April of 1949. The lowest minimum temperature recorded for a period of egg deposition was 36°F. at the beginning of the most intensive deposition period (Feb. 7 to 11) of the year. This was the minimum early morning temperature of the seventh; egg laying occurred in the early morning hours sometime previous to the minimum while the temperature was still descending from the previous day's high of 68°F. The highest minimum temperature during the same period was 55°F. with maximum daily temperatures of 68°F. The highest minimum temperature of any date of egg deposition during the year was 63°F. and the highest maximum temperature was 77°F.

Temperature ranges for each of the eight periods were: Feb. 4-5, 41-64°F.; Feb. 7-11, 36-68°F.; Feb. 20-24, 56-75°F.; Mar. 11, 39-67°F.; Mar. 21, 41-69°F.; Apr. 3, 44-58°F.; Apr. 5, 46-54°F.; and Apr. 20, 53-77°F. Average daily temperatures in degrees Fahrenheit for the same periods were: 54, 52 (aver. 53); 52, 46, 61, 50, 52 (aver. 52.2); 65, 62, 67, 65, 67 (aver. 65.2); 53; 55; 51; 60; and 64. Thus the average daily temperature for all days of egg laying was 56.8°F. Although average temperatures give an indication of conditions under which egg laying takes place, the minimum temperatures are probably of more significance because most egg deposition occurs after midnight when the temperature is usually nearer the minimum. Of the seventeen days during which egg deposition took place in 1949, the minimum temperatures ranged from 36°F. to 63°F., with an average of 48.1°F. Ten of these days had minima of 46°F. or below, four had minima of 53°F. to 58°F., while the remaining three days had minima of 62°F. and 63°F. The average minimum for the period (Feb. 7-11) of most intense egg deposition was 41.6°F. Hence, the majority of egg laying took place before the average minimum temperature reached 50°F.

In both the 1946-47 and 1949 breeding seasons the onset of egg deposition did not take place until after a series of fairly heavy rains had saturated the ground and created an abundance of breeding sites. During November, 1946 the beginning of breeding followed a series of rains of the preceding seventeen days which totaled 12.81 inches and ranged from 0 to 3.25 inches per day. In 1949 the beginning of the breeding season took place on Feb. 4-5 following a preceding nineteen days of heavy precipitation totaling 7.45 inches of rain and 7.0 inches of snow. During this nineteen day period the rainfall ranged from 0 to 2.43 inches per day. Precipitation of the first fifteen days of January totaled 0.03 inches and although some male *triseriata* were noted on the eighth there were no breeding activities evident until after the accumulated rainfall. Sharp drops in temperature following the accumulated

rains, with subsequent sharp increases, were characteristic immediately preceding the onset of the breeding seasons of both 1946 and 1949. In November, 1946 the decrease over a four day period was 29°F. with 24°F. of this amount taking place in twenty-four hours. The subsequent increase in four days was 36°F. with 26°F. the greatest twenty-four hour rise. In Jan.-Feb., 1949 the decrease in temperature in a four day period was 52°F. with a 39°F. drop taking place in twenty-hour hours. Here the subsequent four day rise (at the termination of which egg laying began) was 55° F. with the greatest twenty-four hour increase being 30°F.

More critical studies need to be undertaken before any definite conclusions may be drawn However, it is indicated from these data that in the case of *Pseudacris n. triseriata* temperature and precipitation combined do have an effect in stimulating the frogs in breeding. Large amounts of precipitation in a short period of time, even with relatively high temperatures, are not sufficient to initiate breeding. Protracted periods of rain with relatively high temperatures apparently are necessary for the onset of the breeding at the beginning of the season. In such instances the effect may be two-fold, (a) the soil becomes saturated at sufficient depths with water of a high enough temperature to be stimulatory for the emergence of the animals, and (b) there is an abundance of adequately filled breeding ponds when the animals emerge from their hibernacula. What effect, if any, the decided decrease and subseqeunt increase in temperature following the protracted period of precipitation has on the frogs is not known. From these observations it would appear that *P. n. triseriata* may begin breeding, dependent upon the prevailing climatic conditions, as early as the end of November and continue until the latter part of April in the southeastern section of Texas.

Sites selected for breeding may be quite varied, ranging from very small, shallow, temporary pools to relatively large, deep, semi-permanent ponds. The ponds may be in exposed localities or in rather dense woods, and may have only rotting debris in them or may be dense with grasses, sedges and other vegetation. Ponds in which *triseriata* have been found breeding ranged from four inches to two feet or more in depth, one and a half to thirty feet wide, and three feet to seventy-five yards long. Most of the breeding ponds, however, consisted of temporary rainpools or overflow ponds.

Calling.—When the males arrived at the breeding sites they took up stations around the margin of the pond, usually in the water within two to eight inches from the edge and in general facing the center of the pond, as described by Green (1938) for *P. brachyphona*. Some have been seen calling on the banks a few inches from the water, others may be further out in the water, providing the depth is not over an inch or two or there is vegetation thick enough on which to assume the desired position. During calling the frog assumes a rather distinctive attitude. Two out of every three observed would sit with about three-quarters of their bodies out of water, resting in a squatting position with the folded hind legs held at right angles to, but in the same plane as the body. The front legs would be rested on twigs, leaves, or other material so that the axis of the body was vertical or only a few

degrees from this. This calling position was certainly not one conducive to jumping and in every instance when the animal was disturbed it would release its hold on the supporting material, lower its body and assume a jumping position with hind legs brought along side the abdomen. After arranging himself in the calling position the frog would remain thus for hours on end with no perceptible change.

Calling was not limited to the nocturnal hours, vigorous choruses could be heard during the day throughout the breeding season on both cloudy and sunny days.

Normally the call was composed of five to seven clicks, sometimes only three or as many as eight or nine, increasing in volume and scale. As the frogs began their calls the notes were emitted with a high frequency, each note barely distinguishable from the succeeding, but as the end of the calls were approached there was a diminished frequency so that the terminal two or three notes were quite distinct. Duration of the calls was three-quarters to one and one-half seconds, the interval between successive calls varying from about the duration of the call to five or ten seconds depending on the mood of the caller. The call of one frog apparently illicits a marked effect on others of its kind. If a person remains quietly at a breeding pond there will be noted intervals of silence from time to time. The first calling frog following these periods of silence begins in an indescribably hesitant manner; the pitch of the notes is lower, the number of notes is less, and the duration is very short. After two or three calls of this sort another frog will respond and then others so that gradually the tempo and volume is increased until the individual callers are indistinguishable in ringing chorus. That temperature does have some effect on the call of *triseriata* has been noted previously by Bragg (1948). Suffice it to mention here that some difference can be noticed in duration and interval, especially at relatively low temperatures. At such times the calls are less vigorous and frequent than under optimal conditions.

Manner of egg deposition.—Amplexus takes place in the water, when a female comes into the vicinity of a male's calling station and the latter swims to her and grasps her in an axillary position. From this time until the eggs are deposited the movements are at the discretion of the female. She may remain within a relatively small area or move all about the pond. The male is rather tenacious in his grip on the female, disregarding severe disturbances to retain his hold. A pair located in the ponds under observation in 1949 were picked up and released at least nine times with no attempt on the part of the male to release his mate. This pair was taken to the laboratory where they continued in amplexus until the eggs were laid nine or ten hours later. Selection of the locality in which the eggs are laid seems to be determined primarily by the availability of suitable objects for attachment. In shallow ponds that are highly vegetated egg packets may be scattered. In larger ponds eggs are deposited mainly within five feet of the shore, where there is greater abundance of suitable objects and where the water is not over one and a half feet in depth. Almost any object may be chosen as long as it is

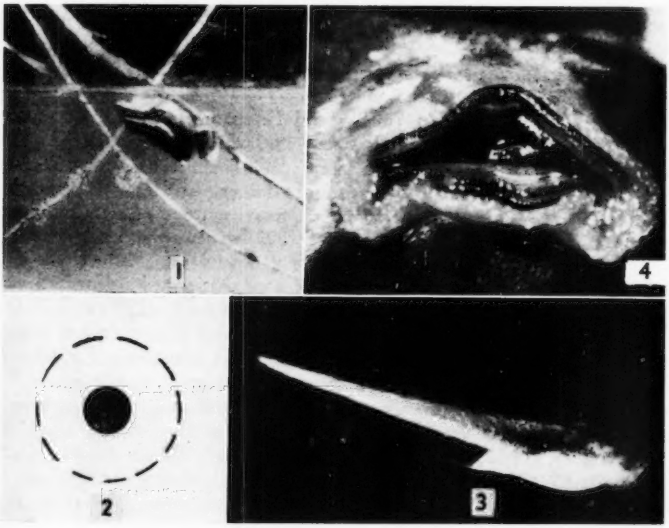
of such diameter that the female can grasp it securely, this includes such items as pine needles, twigs, grass, small roots, sticks, leaves, stems of aquatic plants, etc. The fact that egg masses have previously been depoited on an object does not preclude its use by another frog at a later time. Under such circumstances the older mass is usually at a greater depth than the younger and is larger, limitations of space apparently determining the size of the mass being laid. In the ponds under observation from 1946 to 1949 no egg packets were deposited at depths greater than twelve inches.

An amplexed pair collected about 3:00 PM, February 12, 1949 was taken to the laboratory for closer observation and motion pictures of the egg laying process. The following information is gleaned primarily from this pair and corresponds favorably with actions observed in the field. Nine egg masses were laid during the period of observation from 9:00 PM to 12:30 A.M. Of the material supplied in the aquarium the female utilized a sprig of cedar leaves (one mass), plywood strip (two masses), stems of a composite (three masses), and an oak twig (three masses): nine masses in all. The sequence of these layings was first mass on the cedar sprig, second and third on plywood strip, fourth on a composite stem, fifth on another composite stem, sixth on first composite, seventh and eighth on one oak twig, and ninth on another oak twig. To complete the nine depositions required three hours, the first mass being laid at 9:20 PM, the last at 12:20 AM. Between the first and second laying there was an interval of almost one hour, from the second to the seventh the time between each laying averaged about twelve minutes, varying from ten to fifteen minutes. Between the seventh and eighth and eighth and ninth layings the intervals were twenty-four and thirty-six minutes respectively.

In preparation for the deposition of an egg mass the female would grasp the supporting object with the fore feet, with the hind legs hanging free and somewhat to the side. In this attitude the frog would remain for varying periods of time. Shortly before the actual egg deposition there were series of minor abdominal contractions, each lasting approximately one second and alternating from side to side. These contractions were from five to ten in number. Actual egg extrusion was accomplished by a vigorous bilateral abdominal contraction together with an extreme backward arching of the body, lasting from ½ to 1 second, in a manner similar to that of *Rana septentrionalis* as described by Aronson (1943). This arching of the female tended to extrude the eggs slightly upward toward the vent of the male. At each of these severe contortions some eggs would be emitted in the form of a short string. A normal sized egg mass resulted from no more than three successive contractions, but one such contraction was all that was necessary to produce a small mass. Intervals between successive archings were of about seven seconds duration. The position assumed during these archings would bring the vent away from the stem, but this was immediately corrected at the conclusion of the act by bringing one or both thighs and/or shanks toward the vent and pressing the extruded eggs onto the supporting object. During these final acts of egg extrusion the hind legs may be hanging free or the toes

of the feet would grasp the object haphazardly. Between each arching the female would move upward along the stem three to five millimeters then secure a new hold and continue egg extrusion. Most often the frog was in an upright position above the twig or stem, but on one occasion she emitted an egg mass from an inverted position (Fig. 1).

For the most part the male's actions were passive during the process until the actual egg extrusion. At the beginning of each of the minor abdominal contractions the male would gently squeeze his mate with his front legs. At the time of the vigorous contortions of the female, however, the male evidenced definite excitement. During these periods he squeezed and hunched strongly against the female assuming the same concave position as the female and pressed his vent downward as close as possible to that of the female. In such a position the male held his legs folded up alongside his body. At no time did the frogs break amplexus from collection at 3:00 PM until the egg laying ceased shortly after 12:20 AM. By 12:45 AM the frogs had separated and the male was again calling by 12:50 AM.



Figs. 1-4.—1. *P. n. triseriata* depositing eggs from an inverted position. 2. Diagram of eggs (5×). 3. Photomicrograph of newly hatched larva, showing pigmentation pattern (11.2×). 4. Photomicrograph of mouthparts of *P. n. triseriata* larva (18×).

EGGS

Description of mass.—Egg masses have been described by several workers (Bragg 1948, Smith 1934, Wright & Wright 1949, etc.). Masses noted by

the writer fall well within these descriptions. Of masses measured during 1946-49 the smallest diameter was one-half inch and the greatest one inch. Lengths of masses varied from one inch to two and one-half inches. Average sized packets were about three-quarters by one and a quarter inches. These oblong egg packets were quite distinct in the pond although the jelly was loose and viscid, the latter quality being responsible for the adhering of a fair amount of silt and detritus. The jelly outline of the individual eggs in the mass is not at all distinct, except around the periphery where silt has accumulated, the substance being very clear and transparent. As pointed out by Bragg (1948) the size of the mass is apparently correlated with the abundance of suitable supports, the more abundant the supports the smaller the mass and vice versa. Also Bragg mentions that the depth of the water is a determining factor. In Texas, pools less than four or five inches deep contained smaller egg masses than bodies of water of greater depth regardless of the abundance of suitable supports. Seemingly this is an adaptation of survival value in respect to evaporation. Where there were several masses on a single support they would be immediately next to one another or separated from one to four inches. It was rare to find more than five separate packets on a single support, either from the same or different females.

The number of masses in a given pond was quite variable, from three or four to hundreds. A very small pond of no more than fifteen square feet of surface area was examined in January and February of 1947 and found to contain fifty-eight masses, or approximately 3.86 masses per square foot. This pond was not over fourteen inches deep, and therefore held almost seventeen cubic feet of water. The size of the egg masses was somewhat smaller than normal, but assuming an estimated average of only twenty-six eggs per packet there would potentially be 1508 larvae in the pond, or almost eighty-nine per cubic foot of water. Such a density is not usual, but does give an indication of the great numbers of eggs that may be deposited in a restricted area. An estimate on an average sized pond (240 cu. ft.) with size (40 eggs per mass) and number of egg masses (82) seemingly of normal proportions gives about fourteen potential larvae per cubic foot of water.

Number of eggs per mass varied from as few as seven to as many as 176 in masses counted during the period of these observations. The counts for a total of 35 masses collected at random during these years were: 7, 7, 8, 10, 11, 11, 14, 15, 16, 17, 20, 21, 22, 24, 24, 27, 30, 32, 37, 39, 41, 42, 46, 46, 47, 51, 62, 65, 68, 75, 76, 78, 96, 142, and 176 for an arithmetical mean of 42.8 eggs per mass. There is some indication from these observations that not all frogs void their entire egg complement during one session of amplexus. From examination of several females following egg laying sessions it was noted that although the majority of ovarian contents had been emptied, varying numbers of ripe ova were still retained. A count on one of these animals collected in March, 1948 showed 178 eggs in the two ovaries. Estimates from size of excised ovaries of others compare favorably with this number, and a female in the laboratory retained 565 eggs after having deposited 756. This case may have been a result of abnormal environment, however. Even

with the smaller numbers retained after early breeding, there is thus a possibility of the same females depositing a few egg packets later in the same season.

Description of the egg.—Published accounts of the individual egg of *P. n. triseriata* have been rather contradictory. Smith (1934), describing eggs from Kansas, indicated there were two gelatinous envelopes, the outer not more than 3.0 mm. in diameter. Livezey and Wright (1947) could find but one envelope and indicated a diameter of 4.0 to 7.8 mm., rarely 3.0 mm. Bragg (1948) working in Oklahoma concurs in the presence of only one envelope, but remarks that the envelope is approximately 4.0 mm. with little variation in diameter. A number of specimens from Texas were measured with the aid of an ocular micrometer and found to be as follows: one gelatinous envelope present, range 3.0-6.1 mm., average 4.63 mm.; vitelline capsule 1.3-1.6 mm., average 1.41 mm.; vitellus 1.2-1.5 mm., average 1.27 mm (Fig. 2). These figures are for eggs collected at different years, localities, and early stages (yolk plug to early neural groove) of development. Attempts to demonstrate an inner envelope were futile, even though both fresh and preserved materials were used under various magnifications and light adjustments. The mucoprotein envelope is quite loose, elastic and sticky, adhering to adjacent eggs in the mass rather strongly. In color the vitelli ranged from gray-brown to deep brown above and white to cream below.

DEVELOPMENT

Incubation and larvae.—Under field conditions the incubation period of the eggs was five to eleven days, with a mode of seven days. In 1949 records of water temperatures were kept of the ponds in which the eggs were developing. Eggs requiring six (Feb. 8-13) and seven (Feb. 10-16) days to hatch were in water that varied from 60°F. to 72°F. during the incubation period. Several egg masses kept in the laboratory began hatching four days after deposition and were completely hatched at six days. In this case the water temperature varied from 60° to 78°F. Youngstrom and Smith (1936) have reported eggs of *triseriata* that required only three to five days to hatch.

At hatching the larvae were 5-6 mm. in length, two-fifths of the total length being head and body, and three-fifths the tail. The color of the larvae at this time was generally a medium brown to dark brown as viewed macroscopically, the dorsum much darker than the sides or venter. Under the microscope the pigment cells were in general confined to the dorsal region, with some scattered on the sides of the abdominal area. There were two distinct lines of pigmentation on each side of the head and body (Fig. 3), one running from the anterior tip of the head through the eye to base of tail, the other from the anterior tip of the head arching above the eye and extending to a point where body and dorsal margin of tail musculature meet. Here in the newly hatched larvae can be seen the basic pigmentation pattern of the adults, although it is very shortly obscured by the general darkening of the larvae and is hence indistinguishable until well along in metamorphosis. Pigmentation of the tail was restricted to the dorsal two-thirds of the tail muscu-

lature, the tail crests being almost pigment free. Dorsally the tail crest began about 0.5 mm. behind the posterior margin of the eye and continued ventrally to the vent. In the newly hatched larvae the eye was about 0.3 mm. in diameter. Within a few days the larvae were much darker in color, a deep brown to almost black. Subsequent changes have been adequatelv described by others (Bragg 1948, Hay 1892, Youngstrom and Smith, 1936). In the ponds under observation in 1949 the larval period lasted a minimum of 48 days, from the time of hatching until the first appearance on land, with a maximum of over 80 days. Hind legs were first apparent at 30-34 days and front legs at 38-42 days after hatching.

Many tadpoles reached a larger size before metamorphosis than indicated in Wright and Wright (1949) and Youngstrom and Smith (1936). These authors give the size as 23 mm. and 30-32 mm. respectively, but of those measured in Texas the largest was 40 mm. with many ranging from 34-36 mm. The growth rate and ultimate size of the tadpoles prior to metamorphosis was quite variable and within a few weeks it was impossible to distinguish those produced by the earliest breeders from those produced two or three weeks later. Of the many tadpoles examined all had a tooth ridge formula of 2/3 (Fig. 4), never were any seen with a 2/2 condition. The labial papillae completely surrounded the mouth except for the center 1/3 of the dorsal margin.

Juveniles.—When the juveniles first emerge from the water they may still have a relatively long tail, in some longer than the body; within three or four days, however, it is reduced to a stump. Pigmentation patterns at this time are essentially like those of the adults, but are not as extensive and the general coloration is much lighter. The snout is more rounded in the juveniles. Proportional changes in various anatomical measurements are relatively minor during the growth of the juveniles into adulthood. Snout-vent length in relation to head length and width, snout length, and eye diameter are slightly greater (6-12%) in the adults than in juveniles. Other ratios showed 3.7% or less of change. Average measurements of juveniles completing metamorphosis were: snot-vent 12.4 mm., head width 4.6 mm., head length 4.87 mm., snout 2.0 mm., eye 1.5 mm., leg 19.5 mm., thigh 5.3 mm., shank 5.8 mm., and foot 8.4 mm.

Until the tail is reduced to about 4 mm. the young usually remain within two feet of the pond, leaving and re-entering the water rather frequently. As the tail is further resorbed the animals roam at greater distances from the water in search of food. All found five feet or more from water had the tail present only as a small dark stump which did not project beyond the posterior margin of the thighs. Juveniles in this condition were collected as much as thirty feet from the ponds, though the majority were within fifteen feet. No definite determinations were made of the length of time the juveniles remain in the vicinity of the parent ponds, but indications were that they do so for about four weeks or more.

Food.—Examination of the stomachs of sixteen juveniles, ranging from those with tails about as long as the body to those without tails, indicate that little or no food is consumed until the tail has been almost completely resorbed.

These stomachs were all from specimens collected between April 4 and 23, 1949. Of the eight animals having short to relatively long tails only one contained any food material. This one stomach contained one Eucopepoda, probably *Diaptomus*. Of the eight animals without tails, two had empty stomachs one contained unrecognizable material, and the remaining five contained varying quantities, all Arthropoda. Members of the order Collembola were most frequent, being found in all five stomachs. These were of two families, Entomobryidae, five in one stomach and two in another, and Smynthuridae, three in one stomach, two in each of two stomachs, and one each in two stomachs. Three water mites of the family Hydrachnidae, order Acari, were found in one stomach. Ephemeroptera was represented by one each in two stomachs and one adult coleopteran of the family Chrysomelidae was found in one stomach. The freqeuncy with which the food items were found reflects the relative abundance of food organisms at the time of attaining land status. Collembola alone composed 69.5% of the total number of food items while the other four orders together represented only 30.5%.

Twenty-four stomachs from adult *P. n. triseriata* collected in December, January, February, March, April, and May contained a slightly greater variety of food items than the juveniles, but fewer specimens. Thirteen of the stomachs were empty, two contained only shed skin, another shed skin and a beetle leg, and the remaining eight contained specimens of arthropods of five different orders. Coleopterans were present in three stomachs; three larval Scarabaeidae in one (Feb.), an adult curculionid in another (April), and an unidentifiable beetle leg in one (April). Only one dipteran larva of the family Tipulidae was noted, as was the case with an unrecognizable adult of the Ephemeroptera (both Dec.). One adult hemipteran of the family Anabidae was found (April) and five stomachs each contained a single lepidopteran larva of the family Noctuidae (Feb.).

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Key to the Genera of Tadpoles in the United States and Canada*

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The adult stages of most frogs of the United States and Canada are now fairly well known taxonomically, but comparatively little detailed systematic work has been done on the larval stages. There is a scattered literature of short papers and keys of limited scope by numerous authors, including Bragg, H. M. Smith, and Storer. The work of the Wrights (1929, 1932, 1949) is the most comprehensive that has appeared thus far.

As the Wrights have indicated (1949), much remains to be done before a thoroughly workable key covering all forms in the United States and Canada can be expected. The tadpoles of some forms are undescribed, and many of the known larvae are inadequately characterized. Although a few, such as *Ascaphus truei* and *Rana heckscheri*, have spectacular and unmistakable features, most of the known tadpoles in our area are of very generalized appearance, their specific differences usually of small magnitude and requiring careful and experienced observation. This relatively high degree of similarity is, of course, a major reason for the continued unsatisfactory knowledge of the group. Meanwhile, however, a more extensive use of amphibian larvae in systematics, ecological and food habits studies, and in experimental work emphasizes the growing need for accurate means of identification.

In view of the maze of unsolved problems at the species level, it is thought worthwhile to try focusing attention on generic characters. The present paper offers some general remarks on technique, a simplified generic key, and a brief discussion of identification problems within each genus.

Modern systematic methods, especially population studies, are needed on the larval as well as the adult level. Population and variability problems, age and growth changes, and the role of geographic and ecological factors in relation to the tadpole stage are problems that have scarcely been touched. Nichols' (1937) report is one of the few detailed published studies on any phase of tadpole variation. The gradual but often very considerable changes occurring during larval development add to the difficulty in preparing identification keys and species diagnoses. The tooth rows and the color pattern, especially, may not attain full development until the tadpole approaches its maximum pre-metamorphic size. Two papers by the author (Orton, 1946, 1947) indicate some of the information on growth and variation that can be learned from simple population samples, but the significance—if any—of these results will remain doubtful until similar information has been obtained

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on a substantial number of species, and on geographically remote populations of the same species. Study of series (i.e., population samples) has an additional importance in larval work, for it makes it easier to distinguish between normal variants and the all-too-frequent aberrant specimen. Abnormalities, especially those affecting the tooth rows, are of sufficiently common occurrence to confuse both beginner and specialist.

The importance of proper preservation cannot be over-emphasized. Prompt preservation of fresh specimens *in the field* is desirable, both to prevent the degenerative changes in the soft parts that occur very rapidly in tadpoles and to prevent shedding of the beaks and labial teeth. Ten percent formalin is the recommended preservative. If preservation is delayed, the essential characters may be so obscured that identification is impossible. Details of the soft parts are particularly subject to misinterpretation in poorly preserved material. The loss of horny beaks and labial teeth as a result of faulty preservation should not be confused with the natural shedding of these structures that takes place at the time of metamorphosis, when it is accompanied by atrophy of the lips and extensive changes in the structure of the jaws.

Tadpoles of at least some species are capable of undergoing considerable change in intensity of pigmentation, resulting from response of the melanophores to changing light conditions. This can be observed easily in living material, especially of small species or small individuals in which the skin is still quite transparent. In general, they tend to become very pale at night or in a darkened container, and to become most intensely pigmented when kept in full sunlight. Intensity of pigmentation and distinctness of pattern in preserved tadpoles thus depend to a considerable extent on conditions under which the specimens were preserved, and do not always indicate genetic differences. Not all melanophores respond to light in the same way. In larval *Hyla gratiosa*, for example, the tail fins are pale greenish and translucent in the daytime, and black at night.

Many tadpoles have conspicuous markings of red, yellow, or greenish that disappear more or less completely after preservation. Although such colors are of little assistance in identifying preserved material, they are often highly diagnostic of the living specimens (e.g., red tail fins in *Hyla versicolor*) and should be adequately described. Preservation frequently renders tadpoles more transparent than in life, and this leads to confusion in description of the color pattern, since colors or outlines of certain internal structures may be more or less clearly visible through the skin. The nasal capsules, eyeballs, and patches of subdermal pigment over the brain, spinal cord, and other structures have been variously interpreted as color pattern elements in some published descriptions. In some larvae, notably the Middle American *Rana palmipes*, subdermal pigmentation over the head and back forms a distinctive, externally-visible pattern that is a useful diagnostic character. If such characters are used, it should be clearly stated that they are internal rather than part of the actual skin color pattern. Needless to say, accurate knowledge of the main features of tadpole anatomy, both external and internal, is a neces-

sary basis for taxonomic work on the group.

The magnification used in larval studies should be sufficient so that the rows of labial teeth are sharply visible and can be counted accurately. Magnification will thus vary depending on the size of the specimen, but a binocular dissecting microscope is indispensable for serious study. Since the lips of preserved specimens are often closed or more or less distorted, some means of opening the mouthparts will be needed. For large specimens (about 45 mm. total length, and larger) fine-pointed, curved-tip forceps may be sufficient; but for small larvae a dissecting needle or, better, a spiral-tipped dental "explorer" is more useful. To reduce surface light reflection and make the finer details of the mouthparts more clearly visible, the specimen should be placed in a container of suitable size (e.g., a stender dish) and covered with liquid. Practice will enable one to take advantage of different directions and intensities of light in working out delicate diagnostic structures, such as the lip folds and labial papillae, that are often unpigmented and translucent.

The method of indicating the number of rows of labial teeth varies considerably, and elaborate numerical formulae are sometimes given. The present paper follows the most widely used method, a simple fraction. A tooth row formula of $\frac{2}{3}$ thus indicates that the tadpole has two rows of labial teeth on the upper lip (above the upper beak) and three on the lower lip (below the lower beak). The sequence of counting rows on the upper and lower lips differs in accordance with the different order in which the rows are usually formed. Typically, the rows on the upper lip develop successively from the margin inward, addition of rows occurring centrally, near the upper beak. The opposite is true of the lower lip, the inner rows being the first to form and the addition of rows taking place peripherally. There are complicated exceptions in certain highly specialized exotic larvae.

In many small tadpoles transparency and lack of pigment differentiation make it difficult to interpret spiracular and anal positions, both of which are important in identification. In species in the United States and Canada, the spiracle is either on the midventral line or on the left side of the body; it is midventral in *Ascaphus* and the microhylids, on the left side ("sinistral") in the other genera. The base of the ventral fin is frequently somewhat folded, obscuring the anal tube and making it necessary to straighten the fin in order to determine whether the tube is contained within the fin and opens exactly median on the fin edge or whether it extends downward along the right ("dextral") side of the fin and opens before reaching the edge. Don't forget that right and left sides appear to be reversed in ventral view! In tadpoles with large hind legs the larval anal position may no longer be apparent, but when this stage is reached adult characters of the feet and legs can be used to assist generic identification.

KEY

The key includes only genera that have aquatic larvae; *Eleutherodactylus* and *Syrrhophus* are thus omitted. Recently-hatched stages are also omitted. The generic characters outlined in the key are based on species occurring in the United States and Canada,

and extra-limital species are not necessarily so characterized. This qualification is especially needed for the widely distributed *Rana* and *Hyla*, both of which have undergone much larval specialization in other parts of the world.

1a. Mouthparts simple: no disk-like lip differentiated around mouth, no labial teeth; margins of jaws soft, no horny beaks; sides of upper jaw with a pair of wide soft flaps that overhang lower jaw (Fig. 14). Spiracle median, opens just in front of the median anus (Figs. 2, 7) 2

b. Mouthparts complex: mouth surrounded by a disk-like lip bearing transverse rows of horny labial teeth and more or less extensively edged with papillae; margins of jaws bear hard black beaks (Figs. 15-21) 3

2a. Inner edge of each upper jaw flap with several distinct papillae; spiracular and anal openings more distinctly separated ..... *Hypopachus*

b. Inner edges of upper jaw flaps typically smooth, papillae absent or poorly defined (Fig. 14); spiracular and anal openings very closely adjacent ..... *Microhyla*

3a. Spiracle median, opens on chest region just posterior to lower lip; lips very greatly enlarged, sucker-like; 3 tooth rows on upper lip, 10-12 on lower lip; some tooth rows multiple, consisting of two or more lines of teeth on the same tooth ridge; upper beak flat and plate-like with white edge, lower beak reduced to a small vestige (Fig. 9) ..... *Ascaphus*

b. Spiracle on left side of body (Figs. 3-6, 8). Lips small to moderately large; tooth rows various, but no more than 6 rows on lower lip; each row consists of a single line of teeth per tooth ridge; beaks variously modified but lower beak is of normal size 4

4a. Anus median. Eyes dorsal, tend to be rather close together and relatively small. Marginal papillae present or absent along lower lip; no well-defined submarginal row of papillae on lower lip 5

b. Anus opens on right side of lower tail fin (Fig. 8). Eyes dorsal or lateral, of moderate to large size. Marginal papillae present along lower lip; a ventro-lateral submarginal row of papillae present (Fig. 20) or absent (Fig. 18) on lower lip.. 7

5a. Lips infolded laterally; marginal papillae present only around sides of lips; tooth rows 2/3, the first upper row not reduced in length (Fig. 16). Nostrils often much enlarged ..... *Bufo*

b. Lips not infolded laterally; marginal papillae present along full length of lower lip (Figs. 15, 17). Nostrils small, inconspicuous 6

6a. Papillae border entire lip or absent only from very short median gap on edge of upper lip; 3 to 6 upper tooth rows, about 4 to 6 lower rows; first upper (outermost) row very short (Fig. 15). Beaks sometimes much enlarged and modified with conspicuous median cusps ..... *Scaphiopus*

b. Nearly entire length of upper lip free of marginal papillae. Tooth rows 2/3; first upper tooth row not reduced in length (Fig. 17) ..... *Leptodactylus*

7a. Lips infolded laterally, and typically have well-defined oblique row of submarginal papillae between ends of lower tooth rows and papillae bordering lip (Figs. 20, 21). Moderate to large tadpoles, attaining total length of 45-150 mm., depending on species ..... *Rana*

b. Lips not infolded laterally, and not having well-defined row of submarginal papillae (Figs. 18, 19). Maximum total length usually less than 50 mm. 8

8a. Tooth rows 2/3 (2/2 in some *H. crucifer*), labial teeth numerous and closely crowded. Outline of closed lips subtriangular with apex forward (Fig. 19). Eyes lateral, snout short and blunt (Fig. 11). Nostrils small and inconspicuous. Maximum total length of most species 25-40 mm., some reach 50-60 mm. ..... *Hyla* and *Pseudacris*

b. Tooth rows 2/2, labial teeth relatively fewer and usually rather widely spaced; lip

outline not markedly triangular when closed (Fig. 18). Head narrower; eyes tend to be slightly dorsal, not always visible from ventral view. Nostrils sometimes much enlarged. Tail tip frequently jet black. Maximum total length about 45 mm., but usually considerably smaller ..... *Acris*

MICROHYLA, HYPOPACHUS

The simple type of mouthparts, median spiracle, unusually wide and flat head, and tiny lateral eyes combine to differentiate microhylid larvae (Figs. 2, 7, 10, 14) sharply from all other tadpoles north of Mexico. Differential characters of the several forms are not yet satisfactorily known, though their distribution is such that they can be fairly adequately identified on geographic probability.

ASCAPHUS

The combination of highly specialized mouthparts and median spiracle (Figs. 1, 9) easily distinguishes this peculiar streamlined larva from all other tadpoles in North America. *Rana boylii boylii,* which shares part of the range of *Ascaphus,* has somewhat enlarged mouthparts, but it differs in having a sinistral instead of median spiracle, smaller and less suctorial lips, very different tooth row formula, unspecialized beaks, and in many other obvious details. *Ascaphus truei* is one of the very few North American frogs in which the larva is so unmistakably distinct that it is regularly accepted as basis for locality records.

SCAPHIOPUS

Spadefoot larvae, especially the small eastern forms, are most easily confused with *Bufo,* which they somewhat resemble macroscopically. Tadpoles of both genera have small dorsally-placed eyes, rather wide and depressed body, thin tail, and median anus. *Scaphiopus* (Fig. 15) differs from *Bufo* (Fig. 16) in having marginal papillae around the entire lip edge except for (usually) a very narrow median gap on the upper lip, no lateral infolding of lips, first upper tooth row very short, number of tooth rows greater than ⅔, nostrils small and inconspicuous.

The larvae of the western *hammondii* group reach a larger size (up to 65 mm.) than any local *Bufo,* and are notable for the occurrence of carnivorous individuals with bulging jaw muscles, strong cusps on the beaks, horny spikes at the corners of the jaws, and a hard horny plate on the palate. Specimens variously intermediate in extent of jaw hypertrophy can be found in the same series, and the taxonomic and ecological background of this dimorphic type offers a challenging problem.

Spadefoot larvae are also notable for variability in growth rate, and for having a wider range of variation in number of tooth rows than usual.

LEPTODACTYLUS

A single species, *labialis,* has been recorded in the United States. It is a neotropical form extending northward into the Brownsville area of extreme southern Texas. The tadpole was briefly described by Mulaik (1937), but

few specimens have reached museum collections. The key characters are based on Mulaik's description, specimens from Mexico, and larvae of the closely related Antillean *albilabris* (Fig. 17).

In the area of Texas in which *L. labialis* occurs, its small or medium-sized tadpole (total length 32-40 mm.) could be confused with several other genera, for it is of rather nondescript, generalized appearance. It most nearly resembles *Bufo* and *Scaphiopus*, but differs sharply from *Bufo* in having papillae along the entire edge of the lower lip, and in lacking the deep infolding at the sides of the lips; from *Scaphiopus* it differs in having only two upper and three lower tooth rows, first upper tooth row long, and papillae absent along most of the edge of the upper lip.

BUFO

The tadpoles of *Bufo* (Figs. 3, 12, 16) are a complex group. The genus is remarkably uniform in larval characters throughout its nearly worldwide range. This greatly simplifies generic identification, but makes the species problem correspondingly difficult. Although specific characters and variability of North American forms are still very poorly understood, it is apparent that most of the taxonomic differences are of comparatively small magnitude.

The characters of the mouthparts (Fig. 16) are especially diagnostic of the genus, for in this area only *Bufo* tadpoles have the combination of laterally-infolded lips and absence of papillae along the lower lip. The enlargement of the nostrils, a striking feature of many toad tadpoles and sometimes of *Acris*, is of unknown significance. Most of the *Bufo* tadpoles in the region are quite small (25-35 mm.) but *boreas*, at least, may attain a total length of about 50 mm. or more. Many of the species are very heavily pigmented, often jet black. In some (e.g., *valliceps* and *quercicus*) the tail muscle is blotched or the upper edge dark-barred; in others (e.g., *terrestris-woodhousii* group) the upper half or more of the tail muscle is usually very dark in sharp constrast to the pale lower part.

HYLA, PSEUDACRIS

The close relationship of *Hyla* and *Pseudacris* is reflected in the near-identity of their tadpoles. Although no absolute generic difference between them has been demonstrated, they can usually be separated on the basis of size, color pattern of the tail, and geographic probability. In typical *Pseudacris* tadpoles, the tail muscle is conspicuously bicolor: the upper part dark and the lower part light. Tadpoles can undergo considerable change in color intensity, and *Pseudacris* larvae in a pale color phase may have the tail pattern indicated as a dark midlateral stripe rather than a uniformly dark upper half. The bicolor (or striped) tail muscle pattern is basically characteristic at least of the *P. nigrita* group and *brachyphona*, and perhaps of the entire genus, but in larvae near metamorphosis there is a tendency for the pattern to break up so that dark pigment is more irregularly scattered over the tail muscle. This is especially true of *brachyphona*. In *Hyla* tadpoles the tail muscle is usually

uniformly or irregularly patterned, but at least in *H. andersoni* and *femoralis* and in small larvae of *squirella* a more or less striped pattern is characteristic. Too little is known about pattern development in hylid larvae to permit an adequate discussion of it at the present time.

Small body size and weakly pigmented tail fins are characteristic of most *Pseudacris*, and larger average size and more heavily marked tail fins are more commonly characteristic of *Hyla*. Most forms of *Pseudacris*, so far as known, attain a maximum total length of 25-33 mm., though there is a possibility that *ornata* and *streckeri* may considerably exceed this size. Tadpoles of most *Hyla* reach a maximum total length of 30-45 mm.; *arenicolor*, *cinerea*, and *versicolor* are known to reach 50 mm., and *gratiosa* 60 mm. These size characters will be of little assistance in identifying partly grown specimens, but are helpful in understanding the group as a whole.

Hyla and *Pseudacris* tadpoles have a very characteristic shape (Figs. 4, 11, 19), with deep, globose belly, wide head, very blunt snout, lateral eyes (visible from ventral as well as dorsal view), lips folding into a subtriangular shape with apex forward, tail fins usually highly developed. *Acris* tadpoles closely resemble *Hyla* and *Pseudacris* in proportions but differ in having fewer tooth rows, and in other points noted below in the section on *Acris*. In *Hyla crucifer* the third lower tooth row is usually very short or absent, but in other characters this tadpole would not easily be confused with *Acris*. In tadpoles of the eastern woodfrogs (*Rana sylvatica* sbsp.), the eyes are more widely separated than is usual for *Rana* and these larvae could be confused with hylids, especially in the field. They differ from our treefrog larvae in having laterally infolded lips and a higher number of tooth rows (3 or 4 on the upper lip, 4 on the lower lip). In life, *Rana sylvatica* has a conspicuous yellowish subocular stripe extending from the mouth to a distance well behind the eye. This prominent pattern element is not known to occur in hylid larvae, at least in the United States.

ACRIS

Cricket frog tadpoles (Figs. 5, 18) are the only North American forms in which the tooth row formula 2/2 is a generic character. *Acris* tadpoles most nearly resemble *Hyla* and *Pseudacris*, agreeing with them in the thick blunt snout, dextral anus, complete row of papillae along the lower lip, and lack of lateral infolding of the lips; *Acris* differs in lower tooth row count, usually more widely spaced teeth, less triangular lips, tendency to have a narrower head and more dorsally-placed eyes, and nostrils sometimes greatly enlarged. The tail tip in *Acris* is often jet black and this character, when present, is very conspicuous and generically diagnostic. The black tip, however, is not of constant occurrence.

Since the taxonomy of the cricket frogs is still inadequately understood, it may be worthwhile to point out that the tadpoles of *crepitans* and *gryllus* are readily separable, a least in southern Louisiana (Orton, 1947). Larvae of the recently-described *blanchardi* and *paludicola* have not yet been differentiated.

RANA

The combination of sinistral spiracle, dextral anus, laterally-infolded lips, complete row of papillae along the lower lip, and presence of at least three rows of teeth on the lower lip is adequate evidence to place any tadpole from this region in the genus *Rana* (Figs. 6, 8, 20, 21). In addition, most *Rana* larvae have a clearly defined submarginal row of papillae on the lower lip, adjacent to the ends of the tooth rows (see key and Figs. 20, 21); the head is relatively narrow and tapered (Fig. 8), and the eyes are dorsal rather than lateral.

This genus contains the largest North American tadpoles. There is some overlap in size between the smaller forms of *Rana* and the larger *Hyla* tadpoles, but most *Rana* larvae reach a total length of at least 60 mm., and the larger members of the bullfrog group may sometimes exceed 150 mm.

The larger size and the greater range of specific differences make these tadpoles much easier to identify than is true of most other local genera. Differences in number of tooth rows provide some of the species characters. The most frequent tooth row count is 2/3, but there may be more or fewer rows. In *palustris* and *clamitans* the second upper tooth row is sometimes absent, giving a formula of 1/3. In *pipiens, catesbeiana,* and certain others there is sometimes an additional row on the upper lip, increasing the formula to 3/3. Eastern woodfrogs typically have 3 or 4 rows on the upper lip, 4 on the lower lip. Western woodfrog larvae are still very inadequately known, but show some indication of unusual variability in tooth row count. The formula of 7/6 sometimes attained in *Rana b. boylii* is unusually high for a ranid, but is exceeded in some Old World forms.

Several species groups based on the adult stage are also evident in the larval stage. The group characters are not all suitable for use in keys, and are best listed in synoptic form.

1. WOODFROG GROUP.—Pond-type larvae with short larval period (single season); eastern forms with smaller size and higher tooth row count (total length to 50 mm., tooth rows 3/4 or 4/4); western forms with larger size and more variable tooth row count (total length to 85 mm. in some forms, tooth rows 2/3 to 3/4). Includes *sylvatica* sbsp., *cascadae, aurora* sbsp., and *pretiosa* sbsp.

2. R. BOYLII GROUP.—Larvae more or less streamlined, larval period few months to one year (incompletely known); tooth row formula high, ranging from 4/3 in *tarahumarae* to as high as 7/6 in some *boylii*. Includes *tarahumarae* and *boylii* sbsp.

3. LEOPARD FROG GROUP.—Pond-type larvae with short larval period (single season); tooth row formula lower, 1/3 to 3/3; beaks with wide, heavy, black edges (Fig. 21); nostrils well defined and moderately large; skin thin and translucent. Includes *areolata* and allied forms, *pipiens* sbsp., and *palustris*.

4. BULLFROG GROUP.—Pond-type larvae (though sometimes living in streams) with long larval period, overwintering in larval stage; tooth row formula 1/3 to 3/3; beaks with narrow, thin, black edges (Fig. 20); nostrils very small and often poorly defined; skin of large larvae thick and opaque. Includes *catesbeiana, grylio, heckscheri, clamitans, virgatipes,* and *septentrionalis.*

The North American forms of *Rana* show an especially close correlation between larva and adult in taxonomic problems. For example, the tadpoles of the leopard frogs and their allies have a very strong group resemblance but their specific differences are still poorly understood.

PLATE I

(Lateral views; not drawn to same scale)

Figs. 1-6.—1. *Ascaphus truei.* The most specialized stream-inhabiting tadpole in U. S. and Canada. Mouthparts much enlarged, sucker-like (see Fig. 9 for details). Spiracle median, does not show in lateral view. Tadpole reaches total length of about 50-55 mm. 2. *Microhyla carolinensis.* An easily-recognized tadpole in southeastern U. S. Spiracle median, opens directly below anus. Light spots on body pale orange in life. Total length usually 25-35 mm., sometimes 38 mm. 3. *Bufo woodhousii fowleri.* A typical toad tadpole. Body and upper part of tail muscle often jet black in life, but may be much paler under some conditions. Some species of *Bufo* have very different tail pattern. Nostrils frequently conspicuously enlarged. Tail fins weakly pigmented in most species. Spiracle on left side of body in this and the following three species. Total length of *fowleri* usually about 27-30 mm., sometimes reaches 34 mm. 4. *Hyla cinerea.* Deep body and highly developed tail fins generally characteristic of *Hyla* and *Pseudacris.* Color and pattern, especially of the tail, differ considerably in different species. In most *Hyla,* pattern on tail muscle is quite uniformly distributed, as shown here, not oriented into stripes or bands. In *Pseudacris,* tail muscle is usually conspicuously bicolor, somewhat as in the *Bufo* figured above. Total length of *H. cinerea* usually about 40 mm., may reach 50 mm. 5. *Acris crepitans.* Closely resembles *Hyla* in proportions, but generally has narrower and more *Rana*-like head. Jet black tail tip is a useful diagnostic character, but is not always present. Striped and dappled pattern on side of head is quite constant. Total length usually 32-39 mm., sometimes reaches 45 mm. 6. *Rana pipiens.* A typical *Rana* tadpole. This species often has much more heavily developed color pattern than shown in figure. Total length usually about 60-75 mm., sometimes reaches at least 85 mm.

PLATE I

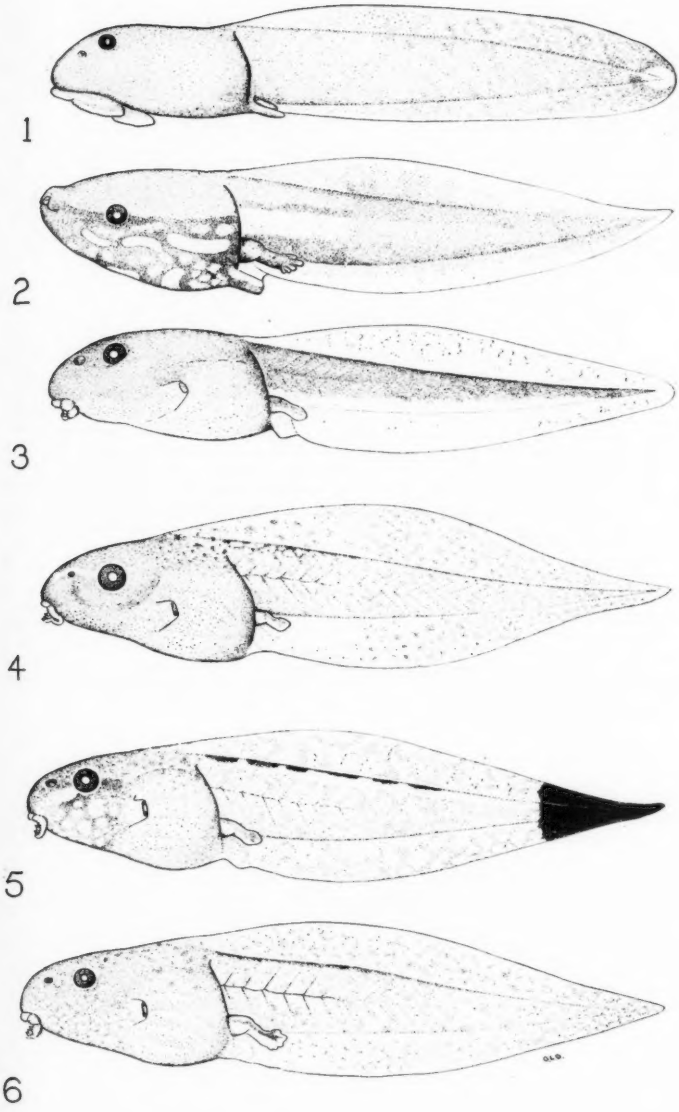
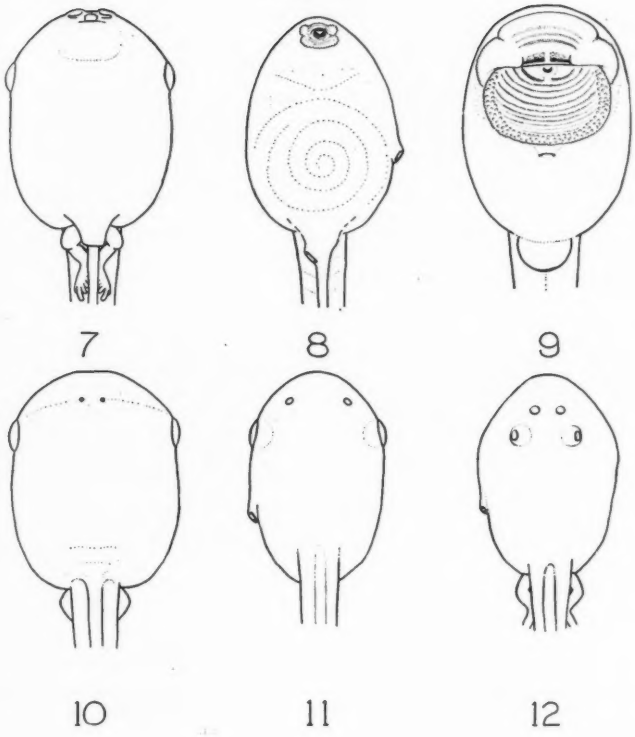


PLATE II

Figs. 7-13.—7. *Microhyla carolinensis* (ventral view). The tiny eyes are completely lateral, visible in ventral as well as dorsal view. Spiracle median, opening below anus, concealing the latter in ventral view. 8. *Rana pipiens* (ventral view). Head narrow, the eyes dorsal in position and not visible in ventral view. Spiracle sinistral (on left side) and anus dextral (on right side), their positions appearing to be reversed in ventral view. 9. *Ascaphus truei* (ventral view). Mouthparts enormously enlarged (compare with Fig. 8), form strong sucker for clinging to rocks in swift current. Tooth rows 3/11 in figured specimen; the three upper rows and ends of several lower rows are multiple, bearing more than one line of teeth on the same tooth ridge. Upper beak flat and plate-like, white-edged; lower beak reduced to a tiny dark crescent. Compare with mouthparts of other tadpoles, Figs. 14-21. Spiracle median, opens just posterior to edge of lower lip. 10. *Microhyla carolinensis* (dorsal view). Illustrates extreme in head width in U. S. tadpoles. Nostrils do not open until metamorphosis, but their position is shown here for comparison with *Hyla* and *Bufo*. 11. *Hyla cinerea* (dorsal view). Lateral eyes, wide snout, and widely separated nostrils are characteristic of *Hyla* and *Pseudacris*. Note sinistral spiracle in this and the following figure. 12. *Bufo woodhousii fowleri* (dorsal view). A typical toad tadpole, with narrowly tapered head, dorsal eyes, nostrils close together. Contrast especially with Fig. 10. 13. Composite diagram illustrating characters of mouthparts. Left half of drawing based on *Bufo*, right half based on *Acris*.

PLATE II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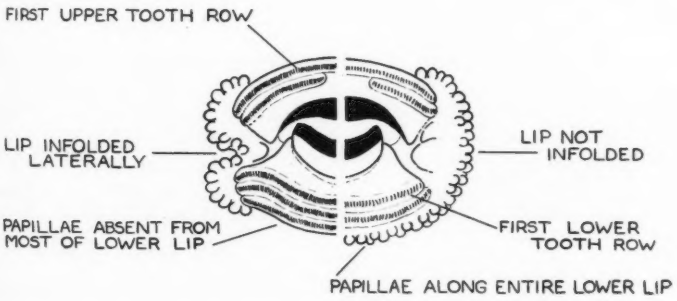
FIRST UPPER TOOTH ROW
LIP INFOLDED LATERALLY
LIP NOT INFOLDED
PAPILLAE ABSENT FROM MOST OF LOWER LIP
FIRST LOWER TOOTH ROW
PAPILLAE ALONG ENTIRE LOWER LIP

13

PLATE III

(Mouthparts)

Figs. 14-21.—14. *Microhyla carolinensis.* Microhylid larvae differ strikingly from all other U. S. tadpoles in lacking lips, beaks, and labial teeth; upper jaw has pair of soft flaps overhanging sides of lower jaw. 15. *Scaphiopus holbrookii holbrookii.* Typical not only of *Scaphiopus* but of most Old World pelobatid genera. Characters shown include moderately high tooth row count (5/6 in figured specimen), lips entirely margined with papillae except above the very short first upper tooth row, lips not infolded laterally, most of tooth rows divided medially. 16. *Bufo woodhousii fowleri.* Typical *Bufo* mouthparts. Tooth rows 2/3, lips infolded laterally, marginal papillae confined to region around sides of lips. 17. *Leptodactylus albilabris.* Mouthparts very similar to the closely related but less well known *labialis* (see text). Tooth rows 2/3; lips not infolded laterally; in this and the following four species, marginal papillae extend along entire lower lip. 18. *Acris crepitans.* Typical cricket frog characters include low tooth row count (only 2/2), labial teeth usually widely spaced, lips not infolded laterally. 19. *Hyla cinerea.* Typical of *Hyla* and *Pseudacris.* On left side of drawing lips are open, on right side relaxed to show subtriangular shape characteristic of many hylid tadpoles. Tooth rows 2/3; labial teeth typically much more numerous and closely crowded than in *Acris;* lips not infolded laterally; marginal papillae extend farther along upper lip than is usual for *Acris, Bufo,* or *Rana.* 20. *Rana catesbeiana.* This and the following figure show typical *Rana* characters. Lips infolded laterally; a more or less well-defined, oblique row of submarginal papillae adjacent to ends of lower tooth rows. As figured here, *catesbeiana* often has tooth row count of 3/3. Narrow black edges of beaks are characteristic of *catesbeiana* and other members of bullfrog group. 21. *Rana pipiens.* Figured specimen has tooth row count of 2/3, but *pipiens* sometimes has a third upper tooth row, as in *catesbeiana.* Wide black edges of beaks are characteristic of *pipiens* and other members of leopard frog group.

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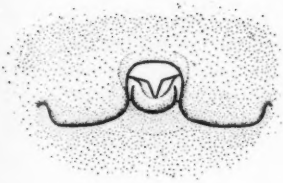
PLATE III



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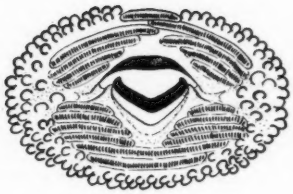

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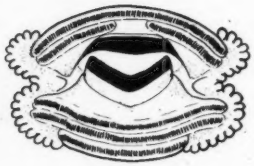

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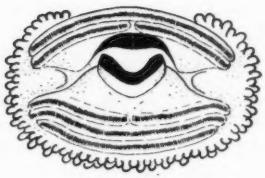

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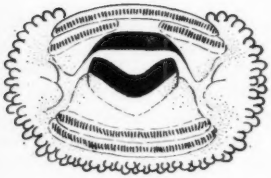

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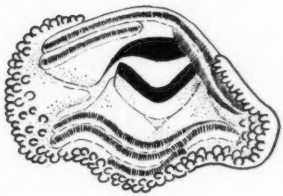

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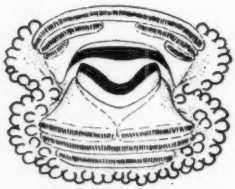

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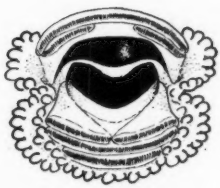

21

The Fishes of the Poteau River, Oklahoma and Arkansas*

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Oklahoma A. and M. College, Stillwater

The Poteau River rises from springs in the uplands of Scott County, Arkansas, and flows westward between the Petit Jean and Poteau Mountains on the north and the Dutch Creek and Walker Mountains on the south into Le Flore County, Oklahoma, about 39 miles from its source. Some 50 miles from its source the Poteau is joined by the Black Fork which rises between Walker and Black Fork Mountains in Scott County, Arkansas. Fourteen miles west of the mouth of the Black Fork, the Fourche Maline joins the Poteau which then bends radically northeastward. The enlarged river winds through an extensive flood plain marked by numerous oxbow lakes, especially in the region near Poteau, Oklahoma. About 27 miles from the river's mouth the Poteau receives Brazil Creek from the west and James Fork from the east. These latter streams with the Fourche Maline and Black Fork are the largest tributaries. The channel again becomes relatively straight about 18 miles from its confluence with the Arkansas River. This portion is now much the same as observed by Meek (1896) at Fort Smith, Arkansas. The Poteau totals 128 miles in length, and with its tributaries drains 1,895 square miles (Anon. 1936).

Frequent floods and high turbidities, except at source locations and during protracted drouths, are normal for the river system. Jordan and Gilbert (1886) also found the Poteau a "rather muddy stream." Stream bottoms are predominantly mud, but shale outcroppings such as the one called Slate Ford, an old crossing near Shadypoint, appear at various places along the Poteau and Fourche Maline. Boulder-gravel situations characterize the Poteau east of Heavener, the upper reaches of the Fourche Maline, and the upper, smaller tributaries.

The watershed consists of folded beds of Pennsylvanian origin (Jackfork and Savanna sandstones, McAlester and Boggy shales) which form mountainous ridges along the valley's upper reaches, progressively eroded downstream to low rolling hills near the mouth.

The principal vegetative types are oak-pine forest along the Poteau above Wister, oak-hickory along the Fourche Maline, and postoak-blackjack below

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Wister (Duck and Fletcher, 1943). Agricultural development has reduced much of the crown cover to hardwood fringe forest at present.

The present survey was one of several undertaken by cooperative agreement with the U. S. Army Corps of Engineers and the Oklahoma Game and Fish Commission for analyses of river fish populations prior to installation of flood control impoundments. The Wister Dam (Fig. 1), under construction at the time of these collections and since filled, impounds 30,000 acre-feet of water at the conservation pool level, having a surface area of 4,000 acres and an average depth of only 7.5 feet. At flood control pool elevation, the surface area will be increased to 23,000 acres.

The survey was conducted during August, 1947, a particularly dry month of an unusually droughty summer. Few tributaries were flowing and at several stations even the Fourche Maline and the Poteau above Wister were intermittent.

As far downstream as Slate Ford the flow was slight until after a heavy shower, attended by a 12-foot rise, occurred on the last night of the survey. There was so little water flowing that collecting for riffle inhabitants was made particularly difficult. The discharge from Lake Carlton (Fig. 1), at Robbers Cave State Park, was reduced to a mere trickle through a small pipe penetrating the base of the dam. Large tributaries, Holston Creek and Black Fork, were not flowing except possibly beneath the gravel and stones on riffles.

Water temperatures were usually high, sometimes warmer than the air, which varied from 27 to 37 degrees Centigrade. The coldest water (18° C.) was that flowing from the bottom of Lake Carlton, and elsewhere temperatures ranged from 21° C. (a small spring near the headwaters of Holston Creek) to 35° C. (mid-day temperature of the Poteau River near Hodgen.)

The pH was somewhat above neutral everywhere except at stations 5 (below Lake Carlton) and 22 (slough at Freeman's Hole on Black Fork) where readings of 6.8 were obtained. The acidity of these waters was caused by an abundance of decaying vegetation. Lake Carlton (since drained) was at that time supporting a dense growth of aquatic plants (largely *Nelumbo*, American lotus) which had produced a layer of decaying vegetation 3 or 4 feet in thickness. Elsewhere the pH ranged from 7.0 to 8.6.

Aquatic vegetation was very abundant in sloughs and deeper pools along the Fourche Maline and Black Fork. The predominant emergent plant was *Dianthera americana* (water willow), which in many places covered the then dry stream beds. This plant was avidly eaten by cattle. In pools of water, particularly on the Fourche Maline and also in sloughs and in Lake Carlton, *Nelumbo, Jussiaea,* and *Najas* were abundant. In many places a luxuriant growth of filamentous algae was found.

1947 COLLECTING STATIONS

Note: Stations 1-9 (incl.) and 13 are located in Latimer County and all others in Le Flore County, Oklahoma.

1. Lake Carlton, Robbers Cave State Park on the Fourche Maline, Aug. 18.
2. Fourche Maline above Lake Carlton near the north boundary of Robbers Cave State Park, Aug. 19.

3. Cunnee Tubby Creek, S33, T6N, R19E and S4, T5N, R19E, Aug. 19.
4. Bandy Creek, S13 and 14, T5N, R19E, Aug. 19.
5. Fourche Maline below Lake Carlton, S25, T6N, R18E, Aug. 19.
6. Coon Creek, S25, T6N, R18E and S30, T6N, R19E, Aug. 19.
7. Fourche Maline at bridge on highway 270 in S11 and 12, T5N, R19E, Aug. 20.
8. Brazil Creek near headwaters, S16, T6N, R21E, Aug. 20.
9. Rock Creek, S15, T6N, R21E, Aug. 20.
10. Longs Creek, S16 and 21, T5N, R22E, Aug. 21.
11. Holston Creek, S26, T5N, R23E, Aug. 20.
12. Holston Creek (west branch), S13, T4N, R22E, Aug. 21.
12A. Holston Creek (headwaters, east branch) S19 and 30, T4N, R24E, Aug. 21.
13. Little Fourche Maline, S4, T5N, R20E, Aug. 21.
14. Fourche Maline northeast of Summerfield, S12, T5N, R23E, Aug. 21.
15. Fourche Maline S7, T5N, R24E, Aug. 22.
16. Reichert Creek 3 miles north of Reichert Store, S27, T5N, R24E, Aug. 22.
17. Conser Creek at Bridge southeast of Reichert Store on Reichert Ranch, S5, T4N, R25E, Aug. 22.
18. Poteau River S31, T5N, R25E, Aug. 22.
19. Cedar Creek, a tributary of Black Fork near Zoe, S34, T4N, R25E, Aug. 22.
20. Cedar Creek at Bridge on Highway 59, S35, T4N, R25E, Aug. 22.
21. Black Fork and Slough at Freemans Hole near Zoe, S28, T4N, R26E, Aug. 22 to 26.
22. Poteau River, near Hodgen, S35 and 36, T5N, R25E, Aug. 24.
23. Unnamed Creek about 1 mile east of Hontubby in S34, T5N, R26E, Aug. 25.
24. Poteau River S29, T5N, R27E, Aug. 25.
25. Hontubby Spring and Poteau River, S33, T5N, R26E, Aug. 24.
26. Sugar Creek, S19 and 30, T5N, R27E, Aug. 25.
27. Black Fork, S6, T4N, R26E, Aug. 25.
28. Poteau River at Slate Ford east of Shadypoint, S36, T8N, R25E, Aug. 26.
29. Brazil and Buck Creeks, S20 and 21, T8N, R25E, Aug. 27.
30. Poteau River at its mouth, S34, T11N, R27E, Aug. 27.
31. Nigger Creek, S34, T8N, R24E, Aug. 27.
32. Oxbow Lake near Station 28 (Slate Ford), S36, T8N, R25E, Aug. 27.
33. James Fork, S13, T8N, R26E, Aug. 28.
34. Gap Creek, S10 and 15, T7N, R26E, Aug. 28.
35. Nail Creek, S21, T7N, R26E, Aug. 28.
36. Poteau River at Bridge near Highway 271 in S27, T8N, R25E, Aug. 28.
37. Oxbow Lakes near Poteau, S2 and 11, T6N, R25E, Aug. 28.

PREVIOUS RECORDS

During explorations for a railroad route from the Mississippi River to the Pacific Ocean, H. B. Hollhausen and Dr. George G. Shumard made collections (1853) in the Poteau and Arkansas Rivers near Fort Smith, Arkansas, and in Sugarloaf Creek, a Poteau tributary (Fig. 1). These were identified and reported by Dr. Charles Girard (1956, 1858, 1860). Only those species recorded for the Poteau, or for Fort Smith without designation of Poteau or Arkansas River, are considered in the annotated list which follows. However, the Arkansas River records and another nearby collection by Mollhausen from "20 miles west of Choctaw Agency" (probably Camp Creek, judging from the map of Marcy, 1853), merit mention here, since in many cases they are type localities and in every instance first records for this region. The species from the Arkansas River near Fort Smith are: *Gobio vernalis* Girard (= *Hybopsis storeianus*); *Alburnus dilectus* Girard, 1856 and *Alburnellus*

dilectus Girard, 1858 (= *Notropis atherinoides atherinoides*); *Alburnops illecebrosus* Girard (= *Notropis illecebrosus*, type locality); *Alburnops blennius* Girard (= *N. blennius*, type locality); *Alburnops shumardi* Girard (types lost, relationship uncertain; see Hubbs and Ortenburger 1929a); *Moniana pulchella* Girard (= *N. lutrensis*, taken also in Sugarloaf Creek); *Exoglossum mirabile* Girard (= *Phenacobius mirabilis*, type locality); *Hybognathus argyritis* Girard (= *H. nuchalis*); *Hyborhynchus perspicuus* Girard, 1856 and *Hyborhinchus perspicuus* Girard (sic.), 1858 (= *Ceratichthys perspicuus*, type locality); *Hadropterus shumardi* Girard (= *Imostoma shumardi*, type locality); and *Pomotis breviceps* (= *Lepomis megalotis*). Those species from 20 miles west of Choctaw Agency are: *Leucosomus incrassatus* Girard (= *Semotilus atromaculatus*); *Luxilis lucidus* Girard (= *Notropis umbratilis*); *Cyprinella umbrosa* Girard (= *N. lutrensis*); *Hyborhynchus tenellus* Girard (= *Ceratichthys tenellus*, type locality); and *Dionda grisea* Girard (= *Campostoma anomalum*).

In 1884 David Starr Jordan and Charles H. Gilbert (1886) collected in the James Fork of the Poteau and the Poteau River at Slate Ford, with "a fine-meshed seine of large size." S. E. Meek (1894) lumped under the heading "Fort Smith" Jordan and Gilbert's collections in these and other nearby streams. In the annotated list we restrict our discussion to species actually taken in the Poteau. However, the record for *Stizostedion vitreum* in Lee's Creek (an Arkansas River tributary flowing most of its length through Oklahoma) and that for *Hybopsis aestivalis* (= *Extrarius aestivalis*, type locality Arkansas River at Fort Smith) merit mention here. The record of *S. vitreum* is of particular interest since this form has not been recorded, even as a probable Oklahoma species.

Fig. 1.—Fishes of the Poteau River, Oklahoma and Arkansas

Dr. Gilbert returned to collect in the upper reaches of the Poteau near Waldron, Scott County, Arkansas, in 1888 (Gilbert, 1889).

Dr. Seth E. Meek (1894, 1896) made two Poteau collections—one in May, 1893, near the town of Poteau, in a natural cutoff lake and adjacent artificial ponds constructed by a railroad company, and a second in May, 1894, in the Poteau River near Fort Smith and in "a few small rocky tributaries near Poteau." Meek (1893) already had discussed previous collections from this stream. In 1894 he again listed previous records, and in so doing introduced several errors of such a nature that his tables are wholly undependable for records of other collectors.

Henry W. Fowler published in 1904 several collections made by Dr. Henry A. Pilsbry in April, 1903, including one at Hartford, Arkansas (probably a branch of the James Fork, certainly in the Poteau drainage), and one at Wister (either the Poteau River or Caston Creek).

A party from the University of Oklahoma Museum of Zoology, directed by Dr. A. I. Ortenburger, collected in Holston Creek 18 miles southwest of Wister, in a pond 2 miles north of Wister, and in the Poteau River 6 miles south of Wister during June and July, 1925 (Ortenburger and Hubbs, 1927). In 1927, collections under the same auspices were made in the Poteau one-half mile north of Waldron, Arkansas, in Brazil Creek 3 miles north of Red Oak, Oklahoma, in the Black Fork and one of its tributaries 6 miles south of Heavener, and in the Poteau 4 miles south and 5 miles west of Fort Smith (Hubbs and Ortenburger, 1929b).

ANNOTATED LIST OF SPECIES

In addition to published records previously cited, unpublished Poteau River collections by Moore Aug. 7, 1939, 4 miles south of Wister; Aug. 8, 1939, at Slate Ford; and April 12, 1941, at Slate Ford are referred to by M_1, M_2, and M_3 respectively. An unpublished Dec. 1, 1939, collection by Dr. John D. Mizelle and an Oklahoma Agricultural and Mechanical College Zoology class at Slate Ford is designated by Miz. Published records, 1947 collection stations (Fig. 1) (numbers such as "15-27" are inclusive), and symbols for other collections are given in that order. New records for the Poteau River are indicated by the absence of literature references.

PETROMYZONIDAE

1. *Ichthyomyzon castaneus* Girard. Chestnut lamprey.—Girard (1858) as *Ichthyomyzon hirudo* Girard at "Fort Smith, Arkansas."

The status of *I. hirudo* was defined by Hubbs and Trautman (1937). Its occurrence in the Poteau will be discussed in a forthcoming paper by Gordon E. Hall.

2. *Ichthyomyzon gagei* Hubbs and Trautman. Southern brook lamprey.—Sta. 21, 22, 27, on basis of ammocoetes.

POLYODONTIDAE

3. *Polyodon spathula* (Walbaum). Paddlefish.—Hubbs and Ortenburger (1929b). The present occurrence will be reported by Mr. Hall in the near future.

ACIPENSERIDAE

4. *Scaphirynchus platorynchus* (Rafinesque). Shovelnose sturgeon.—Girard (1858) as "*Scaphirynchus platirhynchus* Bd."

LEPISOSTEIDAE

5. *Lepisosteus spatula* Lacépède. Alligator gar.—Jordan and Gilbert (1886) as *Lepisosteus tristoechus* (Bloch and Schneider).

6. *Lepisosteus platostomus* Rafinesque. Shortnose gar.—Hubbs and Ortenburger (1929b).

7. *Lepisosteus productus* (Cope). Spotted gar.—Sta. 5, 11, 27, 32.

8. *Lepisosteus osseus oxyurus* Rafinesque. Northern longnose gar.—Jordan and Gilbert (1886), Meek (1896). Sta. 15, 22, and 32.

AMIIDAE

9. *Amia calva* Linnaeus. Bowfin.—Hubbs and Ortenburger (1929b).

Mr. Jones D. Reeves, graduate student in Zoology at Oklahoma A. and M. College, has taken bowfin in an oxbow lake near Fourche Maline River, northeast of Summerfield, Le Flore County. Five specimens (young of the previous year, 130-145 mm. in standard length) were presented to us by Mr. Gordon Hall, who stated that the species was common in fishermen takes on June 9, 1950, both in the lake and below the dam at Wister.

HIODONTIDAE

10. *Amphiodon alosoides* Rafinesque. Goldeye.—Sta. 28.

CLUPEIDAE

11. *Alosa ohiensis* Evermann. Ohio shad.

Moore has seen specimens to be reported as a first State record by Messrs. L. H. Hutchins and G. E. Hall.

12. *Dorosoma cepedianum* (LeSueur). Gizzard shad.—Jordan and Gilbert (1886), Meek (1896), Ortenburger and Hubbs (1927), Hubbs and Ortenburger (1929b). Sta. 8, 14, 28-30, 32, 36. M_1, M_2.

CATOSTOMIDAE

13. *Megastomatobus cyprinella* (Valenciennes). Bigmouth buffalo.—Hubbs and Ortenburger (1929b).

14. *Ictiobus niger* (Rafinesque). Black buffalo.—Hubbs and Ortenburger (1929b). Sta. 11.

15. *Ictiobus bubalus* (Rafinesque). Smallmouth buffalo.—Hubbs and Ortenburger (1929b). Sta. 14, 28.

16. *Carpiodes carpio carpio* (Rafinesque). Northern carpsucker.—Sta. 11, 21, 28-30.

Girard (1856), following his discussion of the types of *C. damalis* (= *C. c. carpio*, by authority of Hubbs, 1930, and Hubbs and Black, 1940) from the Milk River, Montana, mentioned having from the Arkansas River at Fort Smith "half a dozen small specimens . . . closely allied to the preceding species." He did not further commit himself on their identity, nor did he mention them in the 1858 report. Meek (1893, 1894) credited Girard with recording *C. damalis* at Fort Smith, presumably on the basis of this statement, and erroneously synonymized the species with *C. velifer*.

17. *Carpiodes velifer* (Rafinesque). Highfin sucker.—Jordan and Gilbert (1886) as *Ictiobus velifer;* Meek (1896).

Moore has examined specimens taken by Mr. Gordon Hall from the Poteau River below the Wister Dam.

18. *Hypentelium nigricans* (LeSueur). Hogsucker.—Jordan and Gilbert (1886) and Fowler (1904) as *Catostomus nigricans.*

19. *Erimyzon oblongus claviformis* (Girard). Creek chubsucker.—Meek (1896) as *Erimyzon sucetta;* Hubbs and Ortenburger (1929b). Sta. 8, 11, 17, 19, 27, 29.

20. *Minytrema melanops* (Rafinesque). Spotted sucker.—Meek (1896); Hubbs and

Ortenburger (1929b). Sta. 1, 11, 15, 20, 21, 25, 28, 29, 32, 35.

21. *Moxostoma erythrurum* (Rafinesque). Golden redhorse.—Sta. 1, 8, 10, 12, 23, 25, 26, 28.

Hubbs (1930) stated, "Following Jordan (1878), most writers prior to 1896 seem often to have recognized . . . *duquesnii* . . ., but generally referred their examples . . . to '*Moxostoma macrolepidotum*, var. *macrolepidotum*,' and their specimens of *erythrurum* . . . to '*Moxostoma macrolepidotum*, var. *duquesnii*'." Jordan and Gilbert (1886) reported *M. macrolepidotum* (no subspecies indicated) from Slate Ford. Meek (1893) synonymized this with *M. duquesnei*, (sic). *Meek* (1896) reported *M. macrolepidotum duquesnei* (sic.) from the Poteau at Fort Smith and small creeks, lakes, and bayous near the town of Poteau. Following Hubbs (loc. cit.), these are suspected to be *erythrurum*, the only *Moxostoma* subsequently taken in the Poteau. *M. duquesnii* has been found, in Oklahoma, only in the clearest of streams, and it seems unlikely that the Poteau ever met these requirements.

22. *Placopharynx carinatus* Cope. River redhorse.—Sta. 21, 28.

CYPRINIDAE

23. *Cyprinus carpio* Linnaeus. Carp.—Hubbs and Ortenburger (1929b). Now known to be present in large numbers.

24. *Hybopsis storerianus* (Kirtland). Silver chub.—Jordan and Gilbert (1886) correctly identified and as *Notropis illecebrosus*, in part; Meek (1896). Sta. 28, 30, 36. M_3.

The *storerianus* records of Meek and of Jordan and Gilbert were verified by Hubbs and Ortenburger (1929b). Among 35 specimens erroneously referred to *Notropis illecebrosus* by Jordan and Gilbert, we found one example of *H. storerianus*. Jordan and Gilbert also reported *H. amblops* (Rafinesque), which we suspect was a misidentification (see *Notropis amnis*).

25. *Opsopoeodus emiliae* Hay. Pugnose minnow.—Meek (1896); Ortenburger and Hubbs (1927). Sta. 8, 15, 25-27, 29, 31, 32, 34-36. Miz, M_1, M_2, M_3.

26. *Notemigonus crysoleucas auratus* Rafinesque. Western golden shiner.—Meek (1896) as *N. crysoleucas*. Sta. 8, 15, 25-27, 29, 31, 32, 34-36. M_1, M_3.

27. *Notropis atherinoides atherinoides* Rafinesque. River emerald shiner.—Jordan and Gilbert (1886) as *N. dilectus* and as *N. illecebrosus* in part; Meek (1894, 1896) as *N. dilectus*. Sta. 28, 30. M_1, M_2, M_3.

One specimen of *atherinoides* was included in the series erroneously reported by Jordan and Gilbert (1886) as *N. illecebrosus*.

28. *Notropis percobromus* (Cope). Plains shiner.—Sta. 28, 30 and 36. M_1, M_2, M_3.

In the Poteau River this and the preceding species are readily separated on the basis of characters given by Hubbs (1945).

29. *Notropis fumeus* subsp.—Hubbs and Ortenburger (1929b) as *N. umbratilis* (in part). A. I. Ortenburger on June 16, 1931 (Fourche Maline, Latimer County) unpublished. Sta. 7, 8, 15, 28, 29. M_2, Miz.

NOTE.—The International Commission's rulings necessitate correction of the trivial names *duquesnii* and *whipplii* (items 21, 31, 33, and 75 this paper) to *duquesnei* and *whipplei*, and adoption of *Anguilla rostrata* (LeSueur) as the correct name for the American eel (item 59). We concur with Bailey in according full specific status to *Notropis buchanani* (item 38) and in the generic mergers which he proposed, but feel that the many changes which would be necessary to make this paper conform to current nomenclature are not justified. In the last two papers cited above, a subspecific name (*pinnosa*) is made available for *Notropis amnis* (item 35) and several other nomenclatorial matters pertaining to Poteau River fishes are considered.

Hubbs and Ortenburger (1929b) tentatively assigned several specimens from Brazil Creek to *N. umbratilis*, but under the discussion of *N. fumeus* indicated that they might prove to be distinct. Later Hubbs (personal communication) decided that this form is an undescribed subspecies of *N. fumeus* Evermann. Hubbs and Ortenburger (loc. cit.) also stated:

"We have not checked over all of the material recorded by other writers, but have found that Meek's specimens (1891: 138) from Myers, Arkansas, are entirely, and those from the Caddo are in part, the species here called *N. fumeus*."

Myers and the Caddo River are within the range of *fumeus fumeus* rather than the form here considered, but if Meek confused the typical subspecies with *umbratilis* he probably also failed to recognize the Poteau form, which resembles *umbratilis* much more closely. Therefore the Poteau *fumeus* may have been represented in Meek's collections, and perhaps also in collections of other early writers, since Hubbs and Ortenburger (1929b) indicated that some specimens in Girard's type series of *Alburnus umbratilis* look like the Poteau subspecies of *fumeus*.

30. *Notropis umbratilis umbratilis* (Girard). Southern redfin shiner.—Girard (1856) as *Alburnus umbratilis* (type locality: Sugarloaf Creek, Arkansas); Girard (1858) as *Alburnellus umbratilis;* Jordan and Gilbert (1886); Gilbert (1889); Meek (1896); Ortenburger and Hubbs (1927); Hubbs and Ortenburger (1929b). Sta. 1, 3-5, 7-12, 14-29, 31, 33, 34. M_2, M_3, Miz.

Hubbs and Ortenburger (1929b) reexamined the types of *umbratilis* and found all but a few identifiable as *N. u. umbratilis*. The remainder looked like the Poteau subspecies of *N. fumeus* (see *N. fumeus*).

We have examined and verified two of Meek's collections of *umbratilis:* U. S. N. M. 62181, from Sallisaw Creek (Sequoyah County, Okla.) and U. S. N. M. 59161 (Meek, 1894) from a Canadian River tributary near McAlester, Okla.

31. *Notropis illecebrosus* (Girard). Silverband shiner.—Sta. 30.

A single half-grown specimen was taken at the river's mouth by the survey party. Jordan and Gilbert (1886) reported this species from the Poteau River. However, we have examined their 35 specimens (U. S. N. M. 36396) and failed to find *illecebrosus*. Instead of that species, we found the collection to be a complex of *Hybopsis storerianus, Notropis boops, N. whipplii, N. amnis, N. volucellus buchanani, N. volucellus* subspecies, and *N. atherinoides*.

For comparison, Dr. Reeve M. Bailey of the Museum of Zoology, University of Michigan, kindly presented us 5 specimens (U. M. M. Z. 149962) of *illecebrosus* from the Mississippi River 3 miles west of Winfield, Lincoln County, Missouri.

A good series of this species was taken from the Arkansas River by Buford Tatum, Kenneth Testerman and Stanford Mann at Moffett, Oklahoma, and also 6 miles south of Muldrow, Oklahoma, on May 5, 1950. The specimens from Moffett may be regarded as topotypes, since Moffett is adjacent to Fort Smith.

32. *Notropis blennius* (Girard). River shiner.—Meek (1896) as *N. blennius* and as *N. jejunus*. Sta. 30.

Ortenburger and Hubbs (1927: 126) synonymized *jejunus* with *blennius*. Meek (1894) erroneously placed *N. illecebrosus* in synonymy with *blennius* in one place, but did not do so in another part of the same paper. Since his material cannot be reexamined, we assume—with limited confidence—that Meek had *blennius*, which still occurs in the Poteau.

33. *Notropis whipplii* (Girard). Steelcolor shiner.—Girard (1856, 1858) as *Cyprinella whipplii* (type loc. Sugarloaf Creek); Jordan and Gilbert (1886) as *N. whipplei* (sic.), and as *N. illecebrosus*, in part; Meek (1896); Ortenburger and Hubbs (1927) as *N. w. whipplii;* Hubbs and Ortenburger (1929b) as *N. w. whipplii*. Sta. 7, 10, 11, 15, 18, 21, 22, 24, 25, 28, 29, 31, 33. M_1, M_2, M_3, Miz.

Three specimens of *whipplii* were included in the series erroneously reported by

Jordan and Gilbert as *N. illecebrosus.*

34. *Notropis lutrensis lutrensis* (Baird and Girard). Plains red shiner.—Girard (1856, 1858) as *Moniana pulchella;* Jordan and Gilbert (1886); Meek (1896) as *N. bubalinus;* Hubbs and Ortenburger (1929b). Sta. 7, 15, 25, 28, 31, 33, 36. M_2, M_3, Miz.

35. *Notropis amnis* subsp.—Jordan and Gilbert (1886) as *N. illecebrosus,* in part; Hubbs and Ortenburger (1929b) as *N. heterolepis atrocaudalis* (misidentification; see Moore and Cross, 1950). Sta. 7, 15, 22, 25, 28, 30, 36. M_1, M_2, M_3, Miz.

Discovery of four specimens of *Notropis amnis* Hubbs and Greene, among Jordan and Gilbert's *"illecebrosus"* (all misidentified) partly relieves concern regarding the failure of early collectors to report this form, now a very conspicuous member of the Poteau fauna. Their failure to recognize it remains perplexing, but its early presence is now confirmed. *N. amnis* scarcely resembles any other Oklahoma *Notropis,* but superficially is remarkably similar to *Hybopsis amblops.* For this reason, we suggest that Jordan and Gilbert's (1886) record for *amblops,* which has never since been taken in the Poteau, may have been based upon a specimen of *amnis.* Perhaps this also applies to Meek's (1896) record for *amblops* from Goodland in the Red River basin, where *amnis* occurs but *H. amblops* is otherwise unknown.

36. *Notropis boops* Gilbert. Bigeye shiner.—Jordan and Gilbert (1886) as *N. scabriceps* and as *N. illecebrosus,* in part; Gilbert (1889) as *N. heterodon* (?); Meek (1896) as *N. shumardi;* Ortenburger and Hubbs (1927); Hubbs and Ortenburger (1929b). Sta. 1-13, 15-23, 26, 27, 29, 31, 34. M_1.

Of Jordan and Gilbert's 35 specimens erroneously recorded as *N. illecebrosus,* we refer 18 to *boops.*

Meek (1893) recorded *boops* and listed *shumardi* (doubtfully) and *scabriceps* as synonyms, but in his 1894 report covering the same collections listed both *boops* and *shumardi* in his tables. Ortenburger and Hubbs (1927) discussed *shumardi,* pointing out that the types are lost, and Hubbs and Ortenburger (1929b) showed that the types of *N. illecebrosus* are a complex of that species and *boops.* The name *scabriceps* is applied (Jordan, Evermann and Clark, 1930: 125) to a Kanawha River form only. Gilbert's (1889) record of *heterodon* is provisionally regarded as a misidentification of *boops,* since the present known range of *heterodon* does not include the Arkansas River drainage.

N. boops is very abundant in practically all Poteau habitats.

37. *Notropis ortenburgeri* Hubbs. Kiamichi shiner.—Hubbs and Ortenburger (1929b); Sta. 10, 16.

Hubbs and Ortenburger reported a single 23 mm. specimen collected near Waldron, Ark. Our specimens agree with the original description (Ortenburger and Hubbs, 1927) and Hubbs and Ortenburger's (1929b) more complete characterization based chiefly upon Red River material, except that the maximum number of lateral-line scales is increased by one and the body depth enters the standard length 5.3-5.7 times, rather than 4.0-5.0 times.

The axial streak described by Hubbs and Ortenburger (1929b) as going below the lateral band posteriorly in the young (23 mm.) does not do so in our 16 mm. example, but remains high above the band. Our specimens bear a few irregularly-placed, round melanophores on the belly, which is otherwise immaculate.

N. ortenburgeri has been collected in one other locality in the Arkansas River system in Oklahoma: Sand Creek, tributary to Caney River, Osage County, April 13, 1940, by Moore and Dr. F. M. Baumgartner.

38. *Notropis volucellus buchanani* Meek. Ghost mimic shiner.—Jordan and Gilbert (1886) as *N. illecebrosus,* in part; Meek (1896) descr. *N. buchanani;* Hubbs and Ortenburger (1929b). Stations 14, 28, 30, 32 and 36.

Of 35 specimens erroneously recorded as *N. illecebrosus* by Jordan and Gilbert, we identify five with *buchanani.*

This form is quite abundant in quiet waters. Apparently the type locality is not definitely known since Meek simply stated, "A small creek near Poteau"—probably either Nail or Gap Creek, but surely not Sugarloaf since Meek knew the name of that stream.

Hubbs and Greene (1928) indicated the presence of the typical subspecies in Oklahoma and stated, "One lot from near the type locality of *buchanani* fully connects the deep-bodied . . . *buchanani* with the ordinary, less robust phase. . . ." It is evident that Dr. Hubbs later changed his mind concerning this lot since he (1946) listed the southwestern mimic shiner (*Notropis volucellus* subsp.), which surely is not the typical subspecies but another unnamed form mentioned by Moore and Paden (1950).

39. *Notropis volucellus* subspecies.—Jordan and Gilbert (1886) as *Notropis illecebrosus*, in part. Sta. 28.

We refer 3 of Jordan and Gilbert's "*illecebrosus*" to the undescribed form discussed under *N. v. buchanani*, above.

40. *Phenacobius mirabilis* (Girard). Suckermouth minnow.—Jordan and Gilbert (1886); Meek (1896); Hubbs and Ortenburger (1929b). Sta. 28. M_2.

Apparently the distribution of this species in the Poteau has remained remarkably constant, since Jordan and Gilbert found it common at Slate Ford, Meek recorded it as scarce on the basis of his collections at other localities, and recent collections have included it only at Slate Ford, where it is still common.

41. *Hybognathus nuchalis* Agassiz. Silvery minnow.—Jordan and Gilbert (1886); Meek (1894); Meek (1896); Hubbs and Ortenburger (1929b). Sta. 28-30.

Meek (1893, 1894, 1896) considered *H. placita* a subspecies of *nuchalis*, and in the last paper stated, "Some specimens quite slender and more finely scaled than others. No doubt the specimens at hand include *argyritus* and *placita*" (*argyritus* = *nuchalis*). Hubbs and Ortenburger (1929b) reexamined the specimens of Jordan and Gilbert (1886) and Meek (1894) and found them to be *nuchalis*.

The species is now, and apparently always has been, scarce.

42. *Hybognathus placita placita* Girard. Plains minnow.—Meek (1896) (see *nuchalis*). Sta. 30.

43. *Ceratichthys perspicuus* (Girard). Bullhead minnow.—Jordan and Gilbert (1886) and Meek (1896) as *Cliola vigilax;* Hubbs and Ortenburger (1929b) as *Hybargyrus velox* (Girard), in part (see Hubbs and Black, 1947). Sta. 28-30, 36. M_2, M_3.

The early records are indicated as misidentifications by Hubbs and Black (1947), who considered *perspicuus* specifically distinct from *vigilax*, the upper Red River form. Meek, in one instance (1894), erroneously synonymized this with *Pimephales notatus*.

Girard (1858) reported a small specimen of *Ceratichthys* Baird from "near the mouth of Poteau Creek, Arkansas . . . being, according to all probabilities, immature, we must defer its description to a future occasion."

The genus *Ceratichthys* Baird has been placed in the synonymy of *Nocomis* Girard in Opinion 22 of the International Commission on Zoological Nomenclature (Anon. 1910). Hubbs and Black (1947) applied this opinion to their *Ceratichthys* monograph.

Careful examination of the description of *Ceratichthys* Baird (in Girard 1856 and 1858) leaves considerable doubt that it was drawn up from specimens of *Nocomis*. Furthermore, if Girard's specimen (referred to above) is *Nocomis*, it is the only known from the Poteau. The only barbeled minnows known from that river are *Hybopsis storerianus* and *Extrarius aestivalis*.

In the description of *Ceratichthys* Baird, the horizontal, subterminal mouth, the rounded snout overlapping the lower jaw, and the 4-4 teeth can scarcely apply to an Oklahoma *Nocomis*, a genus which Girard described in the same paper including characters contradictory to the *Ceratichthys* diagnosis. The determination of Girard's Poteau specimen is not possible at present.

44 *Ceratichthys tenellus* (Girard). Neosho mountain minnow.—Hubbs and Orten-

burger (1929b) as *Hypargyrus velox,* in part (see Hubbs and Black, 1947: 36). Sta. 8-12, 18, 20-22, 24, 25, 28, 30. M_1, M_2, M_3, Miz.

Judging from Marcy's map (1853) the type locality is probably Camp Creek (T9N, R24E) rather than Sansbois basin, indicated by Hubbs and Black (1947, p. 35 and map 2) as the "approximate location."

Meek (1896) may have had this species in addition to *perspicuus* among specimens he reported as *C. vigilax* (see Hubbs and Black, 1947: pp. 27 and 36). Oklahoma *perspicuus* and *tenellus* are readily distinguished on the basis of characters listed in Hubbs and Black's monograph.

Intergradation between *C. t. tenellus* and *C. t. parviceps* is common in the Poteau.

45. *Hyborhynchus notatus* (Rafinesque). Bluntnose minnow.—Jordan and Gilbert (1886), Gilbert (1889), Meek (1894, 1896), and Fowler (1904) as *Pimephales notatus;* Ortenburger and Hubbs (1927); Hubbs and Ortenburger (1929b); Sta. 1, 4-12, 14-16, 18-20, 31, 33-36. M_1, M_2, M_3, Miz.

All early investigators indicated this species as scarce. It is now one of the Poteau's most abundant fishes.

46. *Campostoma anomalum pullum* (Agassiz). Central stoneroller.—Girard (1856, 1858) as *Dionda spadicea,* "Fort Smith, Arkansas"; Jordan and Gilbert (1886), Gilbert (1889), Meek (1894, 1896), Fowler (1904), and Hubbs and Ortenburger (1929b) all as *anomalum.* Sta. 2-13, 15-29, 31, 33, 35. M_1, M_2, M_3, Miz.

Jordan, Evermann, and Clark (1930) list *Dionda spadicea* as a synonym of *Dionda plumbea.* Since *pullum* alone has been taken in the region from which *spadicea* was collected, we refer Girard's record to this subspecies instead of *C. a. plumbeum.*

Although Meek considered *Campostoma* scarce, we now find it extremely abundant.

AMEIURIDAE

47. *Ictalurus furcatus* (LeSueur). Blue catfish.—Sta. 28.

This is the first record of *furcatus* in the Arkansas River system in Oklahoma. It is common in the Red River.

48. *Ictalurus lacustris punctatus* (Rafinesque). Southern channel catfish.—Girard (1858) as *Pimelodus olivaceus;* Jordan and Gilbert (1886) and Meek (1896) as *I. punctatus.* Sta. 15, 25, 28. M_1, M_2.

Apparently this species has always been abundant in the Poteau.

49. *Ameiurus melas catulus* (Girard). Southern black bullhead.—Girard (1858) as *Pimelodus catulus* (type loc. Fort Smith, Arkansas); Jordan and Gilbert (1886); Meek (1894, 1896) as *melas;* Hubbs and Ortenburger (1929b). Sta. 7, 11, 21, 26, 27, 32, 34.

Meek (1896) reported *A. nebulosus,* doubtless a misidentification, since this species has not since been listed in the Oklahoma fauna.

50. *Ameiurus natalis natalis* (LeSueur). Northern yellow bullhead.—Jordan and Gilbert (1886). Sta. 11, 21, 23, 24, 26-29, 33. M_3.

51. *Pilodictis olivaris* (Rafinesque). Flathead catfish.—Sta. 11, 15, 28. M_1, M_2.

52. *Noturus flavus* Rafinesque. Stonecat.—Jordan and Gilbert (1886).

The single record was reported without comment. The stonecat could hardly be expected to live in the Poteau under present habitat conditions.

53. *Schilbeodes mollis* (Hermann). Tadpole madtom.—Sta. 37.

This single specimen was reported by Moore and Cross (1950) as the first record for the species in Oklahoma. It is now known to be fairly common in the Red River basin.

54. *Schilbeodes nocturnus* (Jordan and Gilbert). Freckled madtom.—Jordan and Gilbert (1886) as *Noturus nocturnus* (orig. desc.). Sta. 7, 15, 22, 24, 25, 28, 29, 33. M_1, M_2, M_3, Miz.

Jordan and Gilbert did not designate the type locality, but stated, "The best specimens obtained (U. S. N. M. 36461) were from the Saline, at Benton." This locality was later (Jordan, Evermann and Clark, 1930) considered the type locality.

55. *Schilbeodes insignis* (Richardson). Slender madtom.—Sta. 11, 12, 17, 18, 21-23, 25-27, 31, 33. Miz.

56. *Schilbeodes miurus* (Jordan). Brindled madtom.—Jordan and Gilbert (1886) as *Noturus miurus*. Sta. 7, 10, 11, 14, 15, 22, 24, 25, 28, 29.

57. *Schilbeodes eleutherus* (Jordan).* Furious madtom.—M_3.

A single specimen is known from the Poteau.

ESOCIDAE

58. *Esox vermiculatus* LeSueur. Grass pickerel.—Meek (1896) as *Lucius vermiculatus;* Hubbs and Ortenburger (1929b). Sta. 5, 7, 9, 20, 23.

ANGUILLIDAE

59. *Anguilla bostoniensis* (LeSueur). American eel.

Mr. Jones D. Reeves, graduate student in Zoology at Oklahoma A. and M. College, stated (personal communication) that he caught several eels from Fourche Maline River 1¼ miles north of Summerfield, Le Flore County.

CYPRINODONTIDAE

60. *Fundulus dispar* (Agassiz). Starhead topminnow.—Meek (1894, 1896) as *Zygonectes escambiae* Bollman.

The species is known still to exist in the Poteau, as well as in the Red River drainage of southeastern Oklahoma.

61. *Fundulus olivaceus* (Storer). Blackspotted topminnow.—Girard (1860) as *Zygonectes pulchellus;* Jordan and Gilbert (1886), Gilbert (1889), Meek (1896), and Fowler (1904) as *Z. notatus;* Ortenburger and Hubbs (1927) and Hubbs and Ortenburger (1929b) as *F. notatus*. Sta. 1-12, 14-29, 31-37. M_1, M_2, M_3, Miz.

Fundulus olivaceus was only recently (Moore and Paden, 1950) removed from synonymy with *notatus*. Girard's description of *Z. pulchellus* obviously was based upon examples of *olivaceus*. This fact, coupled with the present extreme abundance of *olivaceus* and the failure of *notatus* to appear in recent collections, makes it seem safe to refer all past records to *olivaceus*.

We have examined *Zygonectes notatus* (U. S. N. M. 36359) taken by Jordan and Gilbert (1886) in Lee's Creek, Arkansas, and refer the specimens to *Fundulus olivaceus*.

POECILIIDAE

62. *Gambusia affinis affinis* (Baird and Girard). Mississippi mosquito fish.—Meek (1894, 1896); Hubbs and Ortenburger (1929b) as *G. patruelis*. Sta. 1, 14, 15, 18, 22, 24, 25, 27-30, 32-37. M_1, M_2, M_3, Miz.

PERCIDAE

63. *Stozostedion canadense* (Smith). Sauger.—Jordan and Gilbert (1886).

Meek (1896) recorded the species with the notation "Said to be common in the Poteau River at Fort Smith." Moore has examined a specimen recently taken below the Wister Dam by G. E. Hall.

64. *Hadropterus scierus scierus* Swain. Common dusky darter.—Sta. 7, 14, 15, 22, 25, 28, 29, 36. M_1, M_2, M_3.

65. *Hadropterus maculatus* (Girard). Blackside darter.—Jordan and Gilbert (1886) as *H. aspro;* Hubbs and Ortenburger (1929b) as *H. macrocephalus*. Sta. 7, 9, 14, 15,

* Mr. William Ralph Taylor of the University of Michigan (personal communication) stated that this specimen (UMMZ 137904) is not *S. eleutherus*, but probably a hybrid (*S. miurus* × *S. nocturnus*). Moore and Paden (1950: 87) erroneously credited Jordan and Gilbert (1886) with the first Oklahoma record of *S. eleutherus*.

22, 24, 25, 28, 29, 33. M_1, M_2, M_3.

There are some morphological and habitat variations among specimens considered here. Preliminary investigations indicate that the Poteau form and others from the Arkansas River Basin in Arkansas may prove subspecifically distinct. A single specimen from the Fourche Maline is somewhat different from others of the Poteau Basin, but was assigned to this species by R. M. Bailey.

66. *Hadropterus nasutus* Bailey. Longnose darter.—Jordan and Gilbert (1886) as *H. phoxocephalus;* Meek (1896) as *Etheostoma phoxocephalum.* Sta. 22, 28, 29. M_1, M_2, M_3.

Our specimens vary in some respetcs from the description of the types (Bailey 1941), but Bailey (personal communication) relegates them to this form. They are currently under study by Mr. Milton Curd, graduate student of Oklahoma A. and M. College. We provisionally assign the specimens of Jordan and Gilbert and of Meek to this species, although past occurrences of *phoxocephalus* in the Poteau are a possibility.

67. *Percina caprodes carbonaria* (Baird and Girard). Southwestern logperch.—Jordan and Gilbert (1886) as *P. caprodes;* Meek (1896) as *Etheostoma caprodes;* Hubbs and Ortenburger (1929b) as *P. c. caprodes.* Sta. 1, 10, 14, 15, 22, 25, 28. M_2.

Although Hubbs and Ortenburger (1929b) reported *P. c. caprodes,* Hubbs and Lagler (1947) do not include Oklahoma in the range of the typical subspecies. Furthermore, Hubbs (personal communication) has informed us that Oklahoma material is referable to *P. c. carbonaria.*

68. *Cottogaster copelandi* (Jordan). River darter.—Jordan and Gilbert (1886); Hubbs and Ortenburger (1929b). Sta. 12, 14, 15, 18, 22, 24, 25, 28, 36. M_1, M_2, M_3.

69. *Ammocrypta vivax* Hay. Southwestern sand darter.—Jordan and Gilbert (1886). Sta. 28. M_1.

This is the second record for this species in Oklahoma, the only other being that mentioned above. It is now quite rare, only three specimens having been taken in the survey and one, near Wister, in 1939. Jordan and Gilbert's notation, "very abundant," may indicate a marked decline in recent years. Our three specimens were taken following a thunderstorm which caused a sudden rise in the river, which had been very low during fruitless efforts to obtain the species just preceding the storm.

70. *Ulocentra histrio* (Jordan and Gilbert). Harlequin darter.—Jordan and Gilbert (1886). A. P. Blair, see below.

Jordan and Gilbert reported this species as abundant, a status it surely does not occupy at present. Although the 1947 survey crews failed to take the harlequin darter, Dr. A. P. Blair has sent us a single large specimen taken from the Poteau near station 25 on November 25, 1950.

71. *Boleosoma nigrum nigrum* (Rafinesque). Western Johnny darter.—Jordan and Gilbert (1886) as *B. camurum* (misidentification); Hubbs and Ortenburger (1929b). Sta. 8, 25.

We have examined Jordan and Gilbert's (1886) specimens of *B. camurum* (= *B. chlorosomum*) (U. S. N. M. 36402) and assign them instead to *B. nigrum nigrum.*

The 2 forms of *Boleosoma* occupy different habitats in the Poteau River System. *B. nigrum* was associated with the steeper gradients and clearer waters of small tributaries and *chlorosomum* was found in quiet waters of main streams. The two never were taken together.

72. *Boleosoma chlorosomum* (Hay). Bluntnose darter.—Meek (1896) as *Etheostoma chlorosoma;* Ortenburger and Hubbs (1927) as *B. camurum;* Delavan and Creaser (unpubl.), 2 miles west of Wilburton, Latimer County, July 5, 1931. Sta. 4, 28, 29, 32. M_1, M_2.

Apparently this species and the preceding always have been scarce in the Poteau.

73. *Poecilichthys zonalis arcansanus* (Jordan and Gilbert). Arkansas banded darter.

—Jordan and Gilbert (1886). Sta. 10, 11, 18, 21, 22, 24, 25, 27. M_1.

Jordan and Gilbert (1886) described this subspecies in a report on fishes collected in the White River, Arkansas, and listed among other specimens "of this type" one from the Poteau near Hackett City, Arkansas. They did not include *zonalis*, however, in the annotated list of Poteau fishes which immediately follows the White River list. Whether the error is one of omission in the latter paper, or results from transference of data in the former cannot be determined. Waldo L. Schmidt, Head Curator of Zoology of the U. S. National Museum, (personal communication) has informed us that the only information accompanying the specimen lists its collectors and catalogue reference.

74. *Poecilichthys spectabilis pulchellus* (Girard). Plains orangethroat darter.—Gilbert (1889) as *Etheostoma coeruleum lepidum;* Meek (1896) as *E. lepidum;* Ortenburger and Hubbs (1927) as *P. lepidus;* Hubbs and Ortenburger (1929b) as *P. coeruleus pulchellus*. Sta. 2, 7-12, 14, 15, 17-29, 31, 34, 35. M_1, M_3.

Trautman (1930) indicated specific distinctness for *coeruleus* and *spectabilis*. Meek (1896) recorded this form as common, a status maintained at present. Jordan and Gilbert's failure to record this species is difficult to understand.

75. *Poecilichthys whipplii whipplii* (Girard). Western redfin darter.—Jordan and Gilbert (1886), Gilbert (1889), Meek (1896), and Fowler (1904) as *Etheostoma whipplii*. Sta. 2, 7-15, 17-26, 28, 29, 31, 33-37, M_1, M_2, M_3, Miz.

Both Jordan and Gilbert (1886) and Meek (1896) recorded *whipplii* as the most abundant darter in the Poteau, a position which it still retains.

76. *Poecilichthys flabellaris lineolatus* (Agassiz). Striped fantail darter.—Sta. 11, 21, 24, 27.

This species is rare in the Poteau River System.

77. *Hololepis gracilis* (Girard). Western swamp darter.—Jordan and Gilbert (1886) as *Etheostoma fusiforme*. Sta. 14, 15, 22, 24, 25, 28, 29, 32, 33, 35-37. M_1, M_2.

Hubbs and Cannon (1935) pointed out confusion of *fusiforme* and *gracilis* by early writers, and referred Jordan and Gilbert's specimens to the latter species. Though *Hololepis* was taken at many survey stations, it was not abundant.

78. *Microperca proeliaris* Hay. Cypress darter.—Hubbs and Ortenburger (1929b); Sta. 5, 8-10, 14-16, 18-20, 22, 24-29, 32, 34, 35, 37.

Hubbs and Ortenburger's single specimen constitutes the sole previous record for this now-abundant species. We do not believe Gilbert and Meek could have confused *proeliaris* with the following form, which we failed to find in the Poteau.

79. *Microperca microperca* (Jordan and Gilbert). Least darter.—Gilbert (1889) and Meek (1896) as *Etheostoma microperca*.

This species evidently has been supplanted by the preceding in the Poteau. Meek reported it as scarce.

80. *Etheostoma blennioides* Rafinesque. Greenside darter.—Sta. 7, 15, 18, 21, 22, 24, 25. M_1, Miz.

The status of Oklahoma *Etheostoma* has been explained by Moore and Paden (1950).

CENTRARCHIDAE

81. *Micropterus punctulatus punctulatus* (Rafinesque). Spotted black bass.—Ortenburger and Hubbs (1927) and Hubbs and Ortenburger (1929b) as *M. pseudaplites*. Sta. 1, 3-5, 7-12, 15, 17, 19-25, 27-29, 31, 33, 34. M_1, M_2, M_3.

Very probably Jordan and Gilbert (1886) and Meek (1896) had *punctulatus* in addition to the following species.

82. *Micropterus salmoides* (Lacépède). Largemouth black bass.—Jordan and Gilbert (1886); Meek (1896); Ortenburger and Hubbs (1927) and Hubbs and Ortenburger (1929b) as *Aplites salmoides*. Sta. 1, 4, 5, 7, 21, 23, 25, 27-29, 32, 34, 37. M_3.

Jordan and Gilbert (1886) and Meek (1896) reported the largemouth black bass as

"very abundant" and "common," respectively. They must surely have had a complex of this form and *punctulatus*, which greatly outnumbers the largemouth at present.

83. *Chaenobryttus coronarius* (Bartram). Warmouth.—Meek (1896) and Ortenburger and Hubbs (1927) as *C. gulosus;* Sta. 1, 11, 15, 19-21, 25, 27-30, 32, 37.

84. *Lepomis cyanellus* Rafinesque. Green sunfish.—Girard (1858) as *Calliurus formosus*, "Fort Smith, Arkansas"; Jordan and Gilbert (1886); Meek (1894, 1896); Fowler (1904) and Hubbs and Ortenburger (1929b) as *Apomotis cyanellus*. Sta. 1-37. M_1, M_2, M_3, Miz.

The green sunfish was the only species taken at every survey station.

85. *Lepomis humilis* (Girard). Orangespotted sunfish.—Girard (1856, 1858) as *Bryttus humilis*, type locality Sugarloaf Creek; Jordan and Gilbert (1886); Gilbert (1889); Meek (1894, 1896); Ortenburger and Hubbs (1927) and Hubbs and Ortenburger (1929b) as *Allotis humilis*. Sta. 1, 4, 8, 10-12, 14, 15, 18, 22, 25, 26, 28-30, 32, 36. M_1, M_2, M_3, Miz.

86. *Lepomis megalotis* subspecies. Longear sunfish.—Girard (1858) as *Pomotis aquilensis;* Jordan and Gilbert (1886); Gilbert (1889); Meek (1894, 1896); Fowler (1904); Ortenburger and Hubbs (1927) as *Xenotis megalotis fallax;* Hubbs and Ortenburger (1929b) as *X. m. breviceps*. Sta. 1-12, 14-37. M_1, M_2, M_3.

This form is an undescribed subspecies under study by Dr. R. M. Bailey of the University of Michigan.

87. *Lepomis macrochirus macrochirus* Rafinesque. Bluegill.—Jordan and Gilbert (1886) as *L. pallidus;* Meek (1896) as *L. macrochirus* and *L. pallidus;* Ortenburger and Hubbs (1927) and Hubbs and Ortenburger (1929b) as *Helioperca incisor*. Sta. 1, 5, 7, 11, 14, 15, 18-25, 27-30, 32, 34, 35, 37. M_1, M_3, Miz.

88. *Lepomis microlophus* (Günther). Redear sunfish.—Although no redear sunfish were taken in the survey, a hybrid, *L. macrochirus* × *L. microlophus* (see below), attests the presence of *microlophus*, which has become established throughout most Oklahoma drainage systems.

89. *Pomoxis annularis* Rafinesque. White crappie.—Jordan and Gilbert (1886) as *Pomoxys annularis* (sic.); Meek (1894, 1896); Ortenburger and Hubbs (1927); Hubbs and Ortenburger (1929b). Sta. 21, 29, 32. M_3.

90. *Pomoxis nigro-maculatus* (LeSueur). Black crappie.—Sta. 32.

Jordan and Gilbert (1886) and Meek (1893) reported the black crappie from nearby localities, but not from the Poteau.

ATHERINIDAE

91. *Labidesthes sicculus sicculus* (Cope). Northern brook silversides.—Jordan and Gilbert (1886); Meek (1894, 1896); Fowler (1904); Ortenburger and Hubbs (1927); Hubbs and Ortenburger (1929b). Sta. 1, 3-12, 14, 15, 17-29, 31-35, 37. M_1, M_2, M_3.

SCIAENIDAE

92. *Aplodinotus grunniens* Rafinesque. Freshwater drum.—Girard (1858) as *Amblodon grunniens;* Jordan and Gilbert (1886). Sta. 11, 28, 30. M_1.

SPARIDAE

93. *Archosargus probatocephalus* (Walbaum). Sheepshead.—Moore and Cross (1950).

Correspondence and conversations with various ichthyologists have indicated both credulity and incredulity regarding the presence of this species in Oklahoma.

HYBRID COMBINATIONS AND AN ANOMALY

1. *Lepomis cyanellus* × *Lepomis megalotis*.—Sta. 21.

This single specimen is intermediate between *L. cyanellus* and *L. megalotis* with regard

to the length of the following structures: opercular flap, dorsal spines, gill rakers, maxillary, and pectoral fins.

2. *Lepomis humilis* × *Lepomis macrochirus*.—Sta. 5, 14, 25, 32, 34.

These specimens are identified on the basis of the intermediate form of the sensory cavities of the head, the length of the jaw (in some specimens somewhat over-large), the high dorsal spines, and the length of the longest anal spine.

As could be expected, the dorsal spines are quite high, and the palatines bear teeth.

3. *Lepomis macrochirus* × *Lepomis megalotis*.—Sta. 21.

One specimen of this combination is similar to the first-mentioned hybrid, from which it differs in having a smaller mouth, longer dorsal spines, and longer pectoral fins. The opercular flap is not exactly intermediate between those of the parent species, but is somewhat longer than could be expected in *macrochirus*.

4. *Lepomis macrochirus* × *Lepomis microlophus*.—Sta. 32.

Although no specimens of *Lepomis microlophus* were taken by the 1947 survey crews, we have evidence of the presence of the redear in the Poteau system through information from Mr. Gordon Hall, who will report his findings later.

This specimen has very much the aspect of *microlophus*, but the pharyngeal bone is intermediate in form between that of the species listed as parents. Body depth and the general contour of the head also suggest this hybrid combination, although the usual measurements do not confirm intermediacy because of close similarity and variability of the parent species.

A single specimen of *Notropis percobromus* from Sta. 28 is anomalous in that it entirely lacks pelvic fins. Marr (1945) reported a similar condition in *Engraulis mordax* Girard and indicated the phenomenon may have taxonomic and evolutionary significance.

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The Food of a Population of Brown Trout, Salmo trutta Linn., from Central New York

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The brown trout, an introduced species, is well established in New York State and in many localities it has replaced the native brook trout, *Salvelinus fontinalis* (Mitchill). It has gained much favor in this country because of its rapid growth and its ability to survive and reproduce under conditions not tolerated by other species of trout.

Schuck (1943: 228) observed that in New York State brown trout moved upstream in October and November for spawning but returned to their original locations later. In New Zealand where brown trout were introduced, Sapsworth (1945: 70) reports the spawning migrations up the rivers from the lakes to take place from November to April, during which time the fish do not feed. Needham (1930: 85) working with brook trout found that there was a decrease in the amount of food taken during the breeding season as result of lowered water temperatures. The present study records many gravid females and an even greater number of ripe males that were feeding (Table 1).

During the course of investigations in the Ithaca region, a collection of 210 brown trout was made in Taughannock Creek, at Smith Valley, New York. All of the fish were collected on October 5, 1947, between the hours of 3 and 6 p.m. Studies of the trout streams of the Ithaca region by Needham (1929: 222) have indicated that streams flowing through wild, uncultivated lands generally contain more food per unit area than those which flow through cultivated land. Taughannock Creek in the region of the present collection is of an intermediate nature, flowing through dense thickets and open pasture land. The bottom was generally gravel and rubble, although sections of clay or mud bottom were present. No analysis was made of the available food in the present study. Forage fish were abundant in the form of blacknose dace, *Rhinichthys atratulus;* common sucker, *Catostomus commersonnii commersonnii;* creek chub, *Semotilus atromaculatus atromaculatus;* and common shiner, *Notropis cornutus cornutus.* The creek was generally less than 3 feet in depth and under 18 feet in width. There were frequent riffles, and occasional pools as well as areas of emergent vegetation.

Previous reports of stomach analyses of brown trout are numerous, but since the treatment of data by authors varies, it is difficult to express the combined results in figures. Also, many studies in this county and abroad consider several species of trout together without differentiating between them. This limits the use of such data since the species have been shown

by Needham (1938: 121) and others to differ in some respects as to feeding habits. He noted that brown trout feed more at the surface than do brook trout, as is evidenced by the greater number of adult mayflies in their diet. There is little information concerning the winter food of brown trout. The majority of reports are based on summer surveys or on trout taken by anglers during the open season. Slack (1934: 106) and Allen (1938: 343) in England, have reported on winter food of the brown trout, as have Lord (1933: 186) and Needham (1930: 77) for the brook trout in Vermont and New York respectively. Frost (1939: 188) working in Ireland found that the food eaten during the months of November, December and January compared favorably, by weight, with the food eaten during July, August, September and October. The predominant food items were Plecoptera and Trichoptera larvae. It is obvious that the season of the year during which the trout were collected, and the type of food available in the particular area, has a very important bearing on the final analysis. Brown trout, like many other fishes, appear to feed on a great variety of organisms depending upon their availability.

In New York State, reports of stomach analyses of brown trout have been made by Sibley (1928: 106), Needham (1929: 224), Rimsky-Korsakoff (1930: 94), Sibley and Rimsky-Korsakoff (1931: 111), Pate (1933: 151, 152) (1934: 150) and Ocell (1935: 134). These reports based on summer collections of 122 trout show that arthropods comprise about 85 percent of the total food by volume, and of these the aquatic insects are the most important. Fish comprise about 10 percent, although this figure may be low, because of the smaller number of large specimens which account for most of the fish eaten. During the summer months, when terrestrial insects are most numerous, although there was an increase in the percentage of land insects eaten, more than half of their diet was composed of aquatic forms. Pentelow (1932: 106) made the same observation in two English rivers where a collection of 133 brown trout taken during the months of May to September showed a great preponderance of subsurface food, even in months of insect abundance. Clemens (1928: 190, 191) in New York State, found that the bulk of the food of smaller fish consisted of mayfly nymphs and caddis larvae, and approximately 80 percent was obtained in the water. However, for the larger fish, grasshoppers and crickets were the most important and 95 percent was from the surface.

In Michigan, Metzelaar (1929: 149) found brown trout up to 9 inches long to be insect feeders (84 percent) with a decrease in the insect diet as the size of the trout increases. The larger specimens had fed to a considerable extent on young trout (44.4 percent of all fish eaten). He also records (p. 148) brown trout feeding upon lampreys. In British Columbia, Idyll (1942: 448) found Trichoptera to be the most important insect food while salmonids were the principal fish consumed.

In the British Isles, many workers have reported upon the food eaten by brown trout, but few reports contain usable data. Clark (1924: 242)

showed that Diptera, Ephemerida, Trichoptera and Coleoptera were the main items of diet for 749 trout from the Upper Derwent. Swynnerton and Worthington (1940: 186) found the bulk of the food of 101 brown trout taken in July to consist of insects, mainly mayflies and chironomids. Molluscs and fish provided a considerable portion of the food for the larger fish. The fact that molluscs were an important item of food in July is unusual in the light of other reports. Southern (1932: 175) on the basis of 140 specimens from three Irish localities distinguishes between the feeding habits of fishes in alkaline and acid waters. In the alkaline habitats the trout grow quickly, attain a large size, and their food is composed mainly of bottom or mid-water organisms. In acid waters the trout grow slowly, are small, and their food consists mainly of terrestrial insects. Frost (1945: 324) continuing the work of Southern, estimated the available trout food from the fauna of the aquatic mosses. In comparing the weight of the food eaten by the same sized fish from acid waters (349 from Ballysmuttan) and alkaline waters (228 from Straffan) she found that although the number of organisms was similar at the two stations, the fishes from acid waters had eaten less. Southern (1935: 149) found that brown trout in Lough Derg, Ireland, had fed to a great extent upon Cladocera in the plankton during the months of August to November. Seasonal changes in the diet were shown by Allen (1938: 343), in 339 brown trout from Windemere, to fall into three main periods: October to February—feeding on permanent bottom fauna (molluscs and crustaceans), March to July—on temporary bottom fauna (immature insects), and in May to September—on surface food (adult insects). Similar results are shown by Slack (1934: 106) for the winter months of November to March, when the stomach contents of 100 brown trout from the river Test contained Crustacea, Trichoptera and molluscs in greatest numbers. Frost (1939: 149) considered in detail the seasonal types of food in 342 brown trout from two Irish localities. His tables, however, do not show the percentage of the total volume of food for each of the various items of diet, but rather the percentage of occurrence and dominance of various food organisms for each month of the year.

In New Zealand, brown trout were introduced in 1870 and became well established. Sapsworth (1945: 69) reports that Trichoptera form the principal food in the Wellington district and in the majority of the swift flowing streams throughout the country. Mayflies and stoneflies are of lesser importance while Coleoptera, Diptera, and Odonata also figure. Crayfish and seven species of small fish are eaten by the larger trout.

Wild brown trout fry were found in England by Mottram (1931: 220) to feed on *Cyclops* and *Daphne*. Studies of diet transition of newly planted hatchery reared fish bear out the importance of aquatic insects. Raney and Lachner (1941: 106) studied the diet transition of 75 recently planted (autumn) young brown trout and found that in one stream two days after planting, 82 percent of the food was of aquatic origin (100 percent insect) while in another stream three days after planting 95 percent

was of aquatic origin (95 percent insect). After 16 days, aquatic food still predominated (86 percent) and a large part (93 percent) was insect. Ephemerida and Diptera were still most important, although Coleoptera were prominent. After 42 days aquatic organisms still made up a large part (79 percent) with insects predominating (86 percent). In addition to the Ephemerida and Diptera there were Orthoptera, Hemiptera and Plecoptera. The remains of a fish was found in one stomach. Webster and Little (1944: 56) analyzed 40 stomachs, 20 to 27 hours after stocking and found considerable and prompt feeding activity had taken place. The most important food items were mayfly nymphs which made up 90 percent by volume of the total food.

The present method of analysis considers only the stomach contents. Each stomach was emptied into a petri dish, over a one-quarter inch grid. The items were sorted, identified with the aid of a binocular dissecting microscope, counted and carefully estimated as to their volume for each stomach. If only parts of an insect were present it was considered as a whole in the count. The population of brown trout sampled (Table 1) was made up of 39 immature males, 85 immature females, 56 mature males, 28 mature females and 2 undetermined because of poor preservation. The standard length averaged 193 mm; those with food averaged 192 mm, while those with empty stomachs averaged 197 mm. The percentage of mature females without food is three times as great as that of mature males.

TABLE 1.—Summary of the sexual maturity and feeding activity of 210 brown trout from Taughannock Creek, Smith Valley, New York

	WITH FOOD		WITHOUT FOOD	
	Number of fish	Standard length in mm.	Number of fish	Standard length in mm.
Immature male	30	82-209	9	88-183
Immature female	75	76-228	10	152-203
Mature male	51	139-400	5	190-318
Mature female	22	197-431	6	216-408
Undetermined	2	205-266		

The major items of diet as shown in this study by percentage of the total volume of food are as follows: arthropods 70 percent, amphibians 12 percent, fishes 10 percent and mammals 4 percent. In the following discussion of table 2 the major food items are reduced to their components and the figures shown in parentheses after each represent: the number of stomachs containing the item, the percentage of stomachs in which the item was found, the percentage by volume (estimated) of the total food and the percentage of the frequency of occurrence of all food. An asterisk represents less than one-half of one percent. Among the arthropods the greatest volume was made up of Orthoptera, which included grasshoppers (57, 31.7, 13.9, 4.9), field crickets (14, 7.8, 1.0, 0.6) and tree crickets (4, 2.2, *, *).

TABLE 2.—The stomach contents of 180 brown trout, *Salmo trutta*, 82 to 431 mm in standard length from Taughannock Creek, Smith Valley, New York

Food Item	Number of stomachs containing item	Percentage of the stomachs in which item was	Percentage by volume (estimated) of total food	Percentage of the frequency of occurrence of all food
Millipedes	19	10.6	2.4	1.8
Sowbugs	1	.6	*	*
Crayfish	8	4.4	3.2	*
Watermite	4	2.2	*	*
Spiders	27	15.0	1.1	1.0
Orthoptera	75	41.7	15.1	5.7
Neuroptera	6	3.3	*	*
Ephemerida	3	1.7	*	*
Odonata	15	8.3	.9	.5
Plecoptera	48	26.7	2.5	3.0
Hemiptera	69	38.3	10.1	5.9
Homoptera	30	16.7	1.2	2.7
Coleoptera	69	38.3	4.3	8.7
Trichoptera	101	56.1	14.1	22.2
Lepidoptera	4	2.2	*	*
Diptera	33	18.3	1.1	1.8
Hymenoptera	104	57.8	13.9	40.8
Fishes	27	15.0	10.4	1.0
Amphibians	10	5.6	12.3	*
Mammals	2	1.1	3.9	*
Miscellaneous	51	28.3	2.4	3.3

* Less than one-half of one percent.

The second major food item in this study as well as in the studies of other authors were the Trichoptera, of which the genus *Psilotreta* (77, 42.8, 10.6, 8.5) was greatest by volume, but the smaller forms of the genus *Helicopsyche* (65, 36.1, 2.9, 12.9) were found in greater numbers. The third genus represented was *Goera* (14, 7.8, 0.6, 0.8). Mayflies (Ephemerida), which figure so prominently in studies by others, amounted to less than one-half of one percent by volume and frequency of occurrence. Hymenoptera were very important items, and of these, ants (101, 56.1, 12.9, 39.6) comprised the greatest bulk and were the most numerous item of the total diet. Wasps (18, 10.0, 1.0, 1.1) were of lesser importance. Hemiptera were well represented by volume and of these the aquatic forms (34, 18.9, 6.8, 2.5) were twice the volume of the terrestrial forms (56, 31.1, 3.3, 3.4). Aquatic Hemiptera were represented mainly by corixids, notonectids, gerrids, and most important of all the large water bug, *Belostoma*, (26, 14.4, 6.1, 1.6). Coleoptera were represented mainly by terrestrial forms (57, 31.7, 2.7, 6.3) such as staphylinids, carabids and many others although aquatic beetles were also important (40, 22.2, 1.6, 2.3).

The remaining groups of arthropods were each represented by less than three percent of the total volume. The following lists summarize the importance of the insect orders in the diet of the brown trout studied:

By volume	By frequency of occurrence
1. Orthoptera—Most important—	1. Hymenoptera
2. Trichoptera	2. Trichoptera
3. Hymenoptera	3. Coleoptera
4. Hemiptera	4. Hemiptera
5. Coleoptera	5. Orthoptera
6. Plecoptera	6. Plecoptera
7. Homoptera	7. Homoptera
8. Diptera	8. Diptera
9. Odonata—Least important—	9. Odonata

The considerable number of vertebrates found in the present study is the result of the large (192 mm) average size of the trout examined. Of the 27 fishes (5 species) found in the stomachs, *Rhinichthys atratulus* (8, 4.4, 2.6, *) is the commonest form in the stream and in the stomachs. Other species eaten include two *Semotilus atromaculatus atromaculatus*, two *Catostomus commersonnii commersonnii*, two *Salmo trutta*, one *Cottus sp.* and 13 unidentified fish remains. Amphibians were represented by three salamanders (*Gyrinophilus*) and eight frogs (*Rana sp.*) (8, 4.4, 11.3, *). The only identifiable mammal was an adult meadow mouse (*Microtus pennsylvanicus*) (1, 0.6, 2.9, *). Miscellaneous items included feathers, algae, wood, pebbles and a fish hook.

SUMMARY

Previous studies have shown that the brown trout is widespread and well adapted to the warmer streams. It is apparent that more data is needed on winter feeding. The food eaten depends to a large extent upon availability.

A population of 210 brown trout from Taughannock Creek, Smith Valley, New York, collected in October was analyzed for items of diet.

Feeding activity was reduced in mature females.

Food of aquatic origin amounted to slightly more than half (52 percent) of the total volume.

Ants were found in the greatest numbers, while grasshoppers accounted for the greatest bulk. Caddisfly larvae were second in importance by numbers as well as by volume.

Vertebrates accounted for a considerable portion of the total diet (26 percent).

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The Megaloptera and Neuroptera of Minnesota[1,2,3]

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During the years 1947-1949, a study of approximately two thousand Minnesota specimens of Megaloptera and Neuroptera in the collection at the University of Minnesota has revealed that at least forty-one species and nine varieties, included in twenty-three genera, have been taken in the state to this time.

Keys and aids useful for the identification of the adults of the Minnesota species are as follows: Froeschner (47:23)—Mantispidae, Hemerobiidae, Sisyridae, Chrysopidae, Myrmeleontidae and Coniopterygidae; Ross (37:57)—Sialidae; Van der Weele (10:21), Banks (08:27)—Corydalidae: Rehn (39:237), Hungerford (36:85), Smith (34:120) and Enderlein (10:341)—Mantispidae; Carpenter (40:193)—Hemerobiidae, Sisyridae and Polystoechotidae; Smith (32:579; 22:1287), Banks (03a:137) and Schneider (51:1)—Chrysopidae; Banks (27:1)—Myrmeleontidae; and Banks (06a:77)—Coniopterygidae. Larval keys to the families of both orders and to the genera of the Sisyridae have been prepared by Townsend (35:25) and to certain species of the Chrysopidae by Smith (22:1287).

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The paper is divided into two sections, the first dealing with the records of the species of Megaloptera and Neuroptera found thus far in Minnesota, and the second with observations on the bionomics of the megalopterous *Corydalus cornutus* (Linne), *Chauliodes rastricornis* Rambur, *C. pectinicornis*

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3 Published with the permission of the Secretary of the Smithonian Institution.

(Linne) and *Neohermes* sp.[4] The numerals in parentheses following an author's name include the last two numerals of the year of publication preceding the colon and the page number following the colon.

KNOWN RECORD OF MEGALOPTERA AND NEUROPTERA IN MINNESOTA[5]

Megaloptera

SIALIDAE

Sialis mohri Ross (37:74).—May 9 to June 22. Numerous specimens from Anoka, Becker, Goodhue, Hennepin, Houston, Koochiching, Mille Lacs, Pine, Ramsey, Red Lake, Stearns, Todd, Washington and Winona counties. Previously recorded by Ross (37:75) from "Bemiji" (Bemidji); Frontenac, shore of Lake Pepin; Goodhue, Hennepin and Red Lake counties; Ramsey County, Lake "Johonna" (Johanna); Lake Superior; Minneapolis; and Staples.

Sialis velata Ross (37:71).—May 8 to June 28. Numerous specimens from Anoka, Becker, Beltrami, Cass, Clearwater, Crow Wing, Hubbard, Lake, Mille Lacs, Morrison, Olmsted, Pine, Ramsey, St. Louis and Washington counties. Previously recorded by Ross (37:72) from Big Cormorant Lake; Coon Creek; Itasca County; and Itasca Park.

Sialis vagans Ross (37:76)—May 25 to June 25. Thirteen specimens from Cook, Morrison and Pine counties.

Prior to Ross' redefinition (37:73) of *Sialis infumata* Newman (38:500) on the basis of genitalia, this species was recorded from Minneapolis and St. Cloud by Davis (03:449).

CORYDALIDAE

Corydalus cornutus (Linne) (58:551 as *Hemerobius c.*) (Latreille 02:199 as *Corydalus c.*).—June 13 to July 26. Numerous specimens from Anoka, Hennepin, Olmsted, Pine, Ramsey and Sherburne counties. Previously recorded from the state by Davis (03:478).

Chauliodes rastricornis Rambur (42:444).—May 31 to August 8. Numerous specimens from Aitkin, Anoka, Cass, Clearwater, Cook, Houston, St. Louis and Winona counties.

Nigronia serricornis (Say) (24:307, appendix ; ed. LeC. 59:206 as *Chauliodes s.*) (Banks 08:30 as *Nigronia s.*).—June 7 to July 9. Fourteen specimens from Cook, Hennepin and Mille Lacs counties. Previously recorded by Davis (03:460) from St. Cloud, "St. Johns" and Minneapolis, and by Say (24:308, appendix) from Red River "of Lake Winnepeek" (now Lake Winnipeg) (also cited by Hagen 61:191) and Lake of the Woods.

Neuroptera

MANTISPIDAE

Climaciella brunnea var. *occidentis* Banks (11:348).[6]—June 18 to August 27.

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4 Not seen by writer. Determined as *N. concolor* (Davis) (03:462) by Dr. W. T. M. Forbes and J. G. Franclemont. Weele (10:53) has placed *N. concolor* in synonymy with *N. californicus* (Walker) (53:199).

5 The citation of "numerous specimens" in the following annotated list indicates the occurrence of more than fifteen specimens of the species in the collection.

6 No apparent reason for the change in spelling from the original *occidentis* to *occidentalis* of subsequent workers (Spencer, 42:24, determined by Banks; Hoffmann, 36:202, determined by Caudell; index, Trans. Amer. Ent. Soc., 11:348) could be found in the literature. Article 19 of the Rules of Zoological Nomenclature does not appear to be applicable in this case, for in a recent communication (March 20, 1950) from Prof. Banks, the following statement was made: "if *occidentis* is not preoccupied, I don't see why it is not the proper name."

Numerous specimens from Cass, Clearwater, Crow Wing, Dakota, Hennepin, Kittson, Kanabec, Le Sueur, Nicollet, Norman, Polk, Pope, Ramsey, Red Lake, Steele, Todd, Traverse and Washington counties. Previously recorded from shore of Bay Lake, Crow (Wing) County by Hoffmann (36:202, as var. *occidentalis*). *Mantispa brunnea* was described by Say (24:309, appendix; ed. LeC. 59:54) (now *Climaciella b.*, Enderlein 10:360) on the St. Peter's (now Minnesota) River.

Mantispa interrupta Say (25:pt. 2, pl. 25; ed. LeC. 59:55).—March 6 to August 23. Thirteen specimens from Anoka, Hennepin, Houston, Ramsey, Washington and Winona counties.

Mantispa sayi Banks (97:23).—July to August 1. Two specimens from Chisago and Renville counties.

HEMEROBIIDAE

Hemerobius humulinus Linne (58:550).—April 28 to September 16. Numerous specimens from Anoka, Becker, Big Stone, Cass, Clearwater, Douglas, Fillmore, Goodhue, Hennepin, Houston, Kittson, Lake, Marshall, Mille Lacs, Norman, Olmsted, Pennington, Pine, Polk, Ramsey, Red Lake, Rice, St. Louis, Stearns, Swift, Traverse, Wabasha, Washington, Wilkin, Winona and Yellow Medicine counties.

Hemerobius stigmaterus Fitch (55:93).—April 16 to September 30. Numerous specimens from Anoka, Beltrami, Carlton, Cass, Clay, Clearwater, Goodhue, Hennepin, Houston, Lake, Norman, Pine, Polk, Ramsey, St. Louis, Wabasha, Washington and Winona counties. Previously recorded from St. "Anthony's" (Anthony) Park by Banks (05:31).

Hemerobius conjunctus var. *conjunctus* Fitch (Carpenter 40:209).—July 9. One specimen from Clearwater County.

Hemerobius conjunctus var. *pinidimus* Fitch (Carpenter 40:211).—August 1. One specimen from Cass Lake area. Previously recorded by Carpenter (*loc. cit.*).

Wesmaelius longifrons (Walker) (53:291) as *Hemerobius l.*) (Carpenter 40:226 as *Wesmaelius l.*).—June to July 22. Three specimens from Cass, Chisago and St. Louis counties.

Sympherobius amiculus (Fitch) (55:95 as *Hemerobius a.*) (Banks 04:209 as *Sympherobius a.*).—May 31 to August 24. Six specimens from Houston and Ramsey counties. Previously recorded from "Benn" (Bena?) and Eveleth by Carpenter (40:230).

Sympherobius barberi (Banks) (03b:241 as *Hemerobius b.*) (Banks 05:42 as *Sympherobius b.*).—August 9. One specimen from house in Ramsey County. (The possibility of artificial introduction from outside of the state should not be disregarded.)

Boriomyia fidelis (Banks) (97:27 as *Hemerobius f.*) (Banks 04:209 as *Boriomyia f.*).—June 17 to July 30. Two specimens from Clearwater and Cook counties.

Micromus angulatus (Stephens) (36:106 as *Hemerobius* a.) (Hagen 86:280 as *Micromus a.*).—May 10 to September 12. Numerous specimens from Beltrami, Clearwater, Kittson, Lake, Marshall, Mille Lacs, Polk, St. Louis and Washington counties. Previously recorded from Twin Harbors by Carpenter (40:247).

Micromus posticus (Walker) (53:283 as *Hemerobius p.*) (Banks 05:45 as *Micromus p.*).—May 21 to November 1. Eight specimens from Fillmore, Houston, Marshall, Polk and Ramsey counties. Carpenter (40:248) stated that this species was found westward *to* Minnesota.

Micromus subanticus (Walker) (53:282 as *Hemerobius s.*) (Carpenter 40:250 as *Micromus s.*).—June 25 to October. Eleven specimens from Kittson, Norman, Polk, Ramsey, Wabasha and Wilkin counties.

Micromus variolosus Hagen (86:284).—July 29. One specimen from Martin County.

Psectra diptera (Burmeister) (39:973 as *Hemerobius dipterus*) (Hagen 66:376 as *Psectra diptera*).—May 20 to June 5. Two specimens from Ramsey and Washington counties. The westward range (Michigan) of this species as previously reported by Carpenter (40:252) is thus extended.

SISYRIDAE

Sisyra vicaria (Walker) (53:297 as *Hemerobius vicarius*) (Hagen 61:197 as *Sisyra vicaria*).—June 21 to August 21. Numerous specimens from Cass, Clearwater, Kittson, Marshall, Polk, and Traverse counties. The westward range (Mississippi River) of this species as previously recorded by Carpenter (40:254) is thus also extended.

Climacia areolaris (Hagen) (61:199 as *Micromus a.*) (McLachlan 69:21 as *Climacia a.*).—May 30 to August 23. Numerous specimens from Houston, Lake, St. Louis and Washington counties. Previously recorded from Tower by Carpenter (42:50).

CHRYSOPIDAE[7]

Meleoma signoretti Fitch (55:82).—June 15 to August 18. Three specimens from Ramsey and Rock counties.

Chrysopa nigricornis Burmeister (39:980).—May 21 to September 27. Numerous specimens from Clearwater, Douglas, Hennepin, Houston, Marshall, Martin, Olmsted, Polk, Ramsey, Wabasha, Washington, Wilkin and Winona counties.

Chrysopa oculata var. *oculata* Say (Smith 32:587).—April 23 to September 2. Numerous specimens from Aitkin, Anoka, Beltrami, Cass, Chisago, Clearwater, Cook, Crow Wing, Fillmore, Freeborn, Goodhue, Hennepin, Houston, Itasca, Kanabec, Kandiyohi, Kittson, Koochiching, Lake, Le Sueur, Lincoln, Nicollet, Olmsted, Polk, Pope, Ramsey, Rice, Rock, St. Louis, Steele, Todd, Wabasha, Wadena, Washington, Wright and Yellow Medicine counties. *C. oculata* feeding on the pear psylla (*Psylla pyricola* Foerster) was previously recorded by Lugger (00:140).

Chrysopa oculata var. *chlorophana* Burmeister (Smith 32:587).—May 20 to September 11. Numerous specimens from Anoka, Beltrami, Big Stone, Cass, Chippewa, Clearwater, Cook, Faribault, Fillmore, Freeborn, Goodhue, Hennepin, Houston, Itasca, Kanabec, Kittson, Lake, Lincoln, Marshall, Morrison, Nicollet, Norman, Pine, Polk, Ramsey, Red Lake, Rice, Rock, St. Louis, Traverse, Wabasha, Wadena, Washington, Winona and Yellow Medicine counties.

Chrysopa oculata var. *carei* Smith (32:588).—July 8 to August 3. Four specimens from Beltrami, Ramsey, Rice and Todd counties.

Chrysopa oculata var. *xanthocephala* Fitch (Smith 32:589).—July 2 to August 16. Two specimens from Ramsey and Rock counties.

Chrysopa oculata var. *bipunctata* Fitch (Smith 32:589).—May 23 to August 18. Numerous specimens from Chisago, Faribault, Fillmore, Hennepin, Houston, Ramsey, Wabasha and Washington counties.

Chrysopa oculata var. *illepida* Fitch (Smith 32:590).—May 23 to August 14. Numerous specimens from Brown, Cass, Clearwater, Goodhue, Houston, Polk, Ramsey and Todd counties.

Chrysopa oculata var. *separata* Banks (Smith 32:590).—May 29 to August 18. Numerous specimens from Anoka, Carlton, Cass, Chisago, Fillmore, Goodhue, Kittson, Lincoln, Ramsey, Wabasha and Wright counties.

Chrysopa chi var. *chi* Fitch (Smith 32:592).—June 18 to August 21. Four specimens from Cook, Polk and St. Louis counties.

Chrysopa chi var. *upsilon* Fitch (Smith 32:592).—May 26 to July 8. Eight specimens from Beltrami, Kittson, Polk, Ramsey and St. Louis counties.

Chrysopa plorabunda Fitch (55:88).—April 19 to November 18. Numerous speci-

[7] These determinations are tentative pending a study of the terminalia and other characteristics.

mens from Anoka, Benson, Big Stone, Cass, Chippewa, Chisago, Clearwater, Cook, Crow Wing, Faribault, Fillmore, Goodhue, Hennepin, Houston, Kanabec, Kittson, Lac Qui Parle, Lincoln, Lyon, Marshall, Martin, Mille Lacs, Morrison, Nicollet, Norman, Olmsted, Polk, Pope, Ramsey, Rice, Rock, Roseau, St. Louis, Steele, Swift, Todd, Traverse, Wabasha, Wadena, Washington, Winona and Yellow Medicine counties. Previously recorded by Banks (03a:155) from Luverne.

Chrysopa harrisi Fitch (55:90).—August. Two specimens from Brown and Hennepin counties.

Chrysopa harrisi var. *externa* Hagen (Smith 32:596).—March 22 (in house) to September 27. Six specimens from Cass, Ramsey and St. Louis counties.

Chrysopa quadripunctata Burmeister (39:980).—June 14 to August 15. Five specimens from Ramsey and Washington counties.

Chrysopa rufilabris Burmeister (39:979).—October 8. Six specimens from Ramsey County.

Chrysopa majuscula Banks (98:201 as *C. erythrocephala*) (Banks 06b:98 as *C. majuscula*).—August 13. One specimen from Ramsey County.

POLYSTOECHOTIDAE

Polystoechotes punctatus (Fabricius) (93:73 as *Semblis punctata*) (Hagen 61:206 as *Polystoechotes punctatus*).—July to August 13. Five specimens from Cook and Olmsted counties. Carpenter (40:269) noted the absence of this species from the prairie states and Manitoba. The present records, all from eastern Minnesota, are on the northeastern border of the tall-grass prairie.

MYRMELEONTIDAE

Myrmeleon immaculatus Degeer (73:564).—Numerous specimens. The dates for the taking of the larva, making of the cocoon and emergence of the adult run as follows: Anoka County, Fridley Sand Dunes—July 12, July 23, August 11; Houston County—May 23, June 14, July 1; May 24, May 31, June 22; May 24, June 6, July 10; May 24, June 10, July 4; Washington County—(unknown) July 28, August 13 and (unknown), July 23, August 13. Other dates for capture of adults include July 10 to August 13 from Ramsey, Wabasha and Washington counties.

Cryptoleon nebulosus (Olivier) (11:127 as *Myrmeleon nebulosum*) (Banks 07:153 as *Cryptoleon nebulosum*).—June 14 to July 12. Five specimens from Anoka, Clearwater and Houston counties and Cass Lake area.

Cryptoleon signatus (Hagen) (87:215 as *Maracanda signata*) (Banks 01:330 as *Cryptoleon signata*).—June 30 to August 3. Fourteen specimens from Anoka and Carver counties.

Hesperoleon abdominalis (Say) (23:163; ed. LeC. 59:173 as *Myrmeleon a.*) (Banks 13:65 as *Hesperoleon a.*).—June 15 to September 2. Numerous specimens from Anoka, Big Stone, Dakota, Faribault, Goodhue, Hennepin, Kittson, Morrison, Norman, Olmsted, Ottertail, Pine, Pipestone, Polk, Pope, Ramsey, Red Lake, Rice, Rock, Scott, Sherburne, Stevens, Traverse, Wabasha and Washington counties. Previously recorded by Banks (27:39) from St. Anthony Park.

Hesperoleon nigrilabris (Hagen) (88:72 as *Brachynemurus n.*) (Banks 13:65 as *Hesperoleon n.*).—July 12 to August 8. Ten specimens from Anoka County.

CONIOPTERYGIDAE

Coniopteryx vicina Hagen (61:197).—May 24 to August 31. Two specimens from Houston and Ramsey counties.

Conkentzia hageni Banks (06a:82).—April 27 to August 24. Five specimens from Hennepin and Ramsey counties.

Malacomyza westwoodi (Fitch) (55:98 as *Aleuronia westwoodii*) (Banks 06a:84 as *Malacomyza westwoodi*).—May 26 to August 1. Three specimens from Fillmore, Houston and Pope counties.

NOTES ON THE BIONOMICS OF CORYDALUS CORNUTUS (Linne), CHAULIODES RASTRICORNIS Rambur, C. PECTINICORNIS (Linne) AND NEOHERMES SP.

Much of the literature on the bionomics of the Megaloptera and Neuroptera has been summarized by Balduf (39:214), who recognized that the life histories of several species have never been completely described. Other more important comprehensive works on the bionomics of the Neuroptera include those by Killington (36:1; 37:1) and Withycombe (23:501; 25:303) on the British species of Neuroptera.

The majority of the following observations were made at the University of Minnesota, St. Paul campus, during the period from May 19 to June 22, 1949. Although the writer witnessed the mating of *Corydalus cornutus* (dobsonflies) three times, it is regretted that the difficulty of seeing details in the dim light, coupled with the lack of proper photographic equipment and time for a more comprehensive study has permitted observations of a general nature only.

On May 19, 1949, twenty-five prepupae of *Corydalus cornutus* and seven of *Chauliodes rastricornis* (fishflies) were collected from cells under rocks on the banks of the Snake River, close to its junction with the St. Croix River in Pine County by Dr. C. E. Mickel, J. W. Barnes and the writer. All of the specimens of *C. rastricornis* were taken in moist soil near the water's edge, whereas many of the hellgrammites were found in drier soil farther away. The bark of nearby stumps and logs was not examined, although fishfly prepupae have been actually observed in such situations by Brimley (08:133), Needham (01:544), Weed (89:8), Walsh (63:262) and Haldeman (48:159).

Of the hellgrammite prepupae reared at room temperature by the writer, the first pupated on May 26 and the last on June 1; the first adult emerged on June 6 and the last on June 12. Although the length of the prepupal periods in the cell prior to capture were unknown, the pupal periods under conditions of captivity (wide-mouthed pint jar with soil watered daily, water container, stone or surface object and twig for emergence) ranged from seven to thirteen days, with an average of nine days, a record agreeing essentially with that of Davis (03:475). The same writer also observed that the "time spent in the nest before the larval skin is shed," or prepupal period, varied from one to fourteen days.

On June 7 a second lot of twelve hellgrammite prepupae was obtained by Dr. P. H Harden and the writer a few miles from the first site of collection. Of these, the first pupated on June 10 and the last on June 13, with an average of eight days for the pupal period. Of twenty-four (out of twenty-five) first lot adults which emerged, the sex ratio was 5:1, with twenty males and

four females; of eight (out of twelve) second lot adults which emerged, the sex ratio was 3:1 or six females to two males. Rough measurements of the lengths of the prepupae indicated no apparent length correlation with the sex of the adults. Haldeman (48:159) reported the larger head and mandible size and the small "tubercle" on the sternum of the prothorax of the male larvae.

Pupation of two fishfly prepupae took place on May 30 with one female emerging on June 3 and another on June 7. Pupal records were not kept of the other prepupae because of the fact that the cells were not made under stones or objects (although available in each jar) as in the case of the dobsonflies and disturbance while searching for the cells seemed to add to the mortality rate. By June 7 five females had emerged. Although the exact lengths of the prepupal periods were unknown, the combined prepupal and pupal periods while in captivity ranged from fourteen to nineteen days with an average of sixteen days. Previous reports of the pupal periods for species of *Chauliodes* in captivity include those by Brimley (08:133) seventeen to thirty days; Davis (03:457) "not longer than two weeks"; Needham (01:545) about two weeks; Weed (89:8) "no longer than eight days"; Moody (77:52) twelve to fourteen days; Walsh (63:263) about three weeks; and Haldeman (48:159) in the cell "probably not less than two weeks" "awaiting its change."

All of the fishflies emerged at night through a hole almost perpendicular to the surface of the soil. The manner of emergence was not seen although it was noted that the pupal skin of one was found protruding halfway out of the cell (3 cms. deep) (also reported by Needham 01:546 in a hemlock log), another on the soil about 2 cms. away from its hole, and a third in a water container embedded in the soil of the jar.

The majority of the dobsonflies emerged overnight. A few hours before emergence, all had constructed oblique passageways with an opening directly beneath one side of the object in the jar. The last larval skins were shed in the cells, where they rapidly disintegrated unless removed within a few hours. In many instances, one to three days prior to emergence, the pupae worked their way to and were visible through the sides of the jars.

At emergence, the pupal skin was split with violent movements at the dorsum of the thorax, which was curved toward the opening of the burrow with the head bent caudad. The integument was worked off at both ends simultaneously, the imago using the stone or other object above as a brace, so that the antennae, mandibles of the male, which had been pleated in accordion-like fashion in the pupal skin, and wings were stretched to full length. In all cases observed, not more than one half to two minutes were required for the process and the pupal skin was shed at the caudal end of the cell. The adult emerged from the soil with wings, antennae and mandibles full-sized. The two individuals, which were placed as prepupae in jars comparable to those already described except for the lack of a stone or other surface object, pupated but appeared unable to shed their pupal skins, although a darkening of the integument occurred and the wing pads of the exarate pupae fluttered as in flight.

With the assistance of the twigs in each jar, the adults immediately crawled

to the wires of the cages or tops of the twigs, where they hung with arched bodies, antennae directed backwards and wings folded vertically above the back, similar to Odonata (Buchsbaum 48:292, pl. 4, fig. 3) for approximately twenty to sixty minutes or longer while sclerotization was completed (mandibles, tibiae, tarsi, antennae, wings, etc.). The white spots on the wings were not visible until later (three fourths of an hour in one case).

After the wings had assumed their normal rooflike position, adults of both species were transferred to other cages and unsuccessful attempts were made to feed them with small insects (Hemiptera, Homoptera, Diptera, lepidopterous larvae). However, a concentration of approximately three parts of water to one part of honey was eagerly consumed at an average daily rate of one eighth of a standard dropper full by the fishflies and one half to one and one half droppers full by the dobsonflies, the amount decreasing two or three days prior to death as the insects gradually lost their vigor with each succeeding day of adult life. Maple syrup and water solutions were rejected.

The attraction of a fermented syrup of molasses, water and sugar (Champlain and Kirk 26:288) and sugar (Brimley 08:133) for *Chauliodes pectinicornis* (Linne) has been previously reported. Recently, Dr. W. T. M. Forbes of Cornell University, Ithaca, New York, and J. G. Franclemont of the U. S. National Museum, Washington, D. C., have informed the writer of collections of Megaloptera at bait traps, consisting of a mixture of fermented bananas, brown sugar, molasses and beer "painted" on various trees, shrubs, etc. in New York from dusk to midnight during the years 1934-1941. Franclemont collected and observed several specimens of both sexes of *Corydalus cornutus, Chauliodes pectinicornis, C. rastricornis* and two specimens of *Neohermes* sp. (collected July 29, 1941 and August 11, 1947) feeding on bait applied to approximately one hundred trees, shrubs, etc. along Six Mile Creek (approximately three miles from Ithaca) from late May through early August. It was noted that the fishflies were generally seen at bait in the more open places whereas the dobsonflies were observed in deeper woods also. At McLean Bogs (approximately fourteen miles from Ithaca), a more hilly area, Franclemont noted both species and sexes of *Chauliodes* at the traps during the same period, but no dobsonflies. At Minetto, a "large block" of both sexes of *C. pectinicornis* and *C. rastricornis*, which had "probably flown no more than a few feet from their breeding area" in a "very swampy area" on June 21-23, 1938, was collected at bait by Forbes. In general, the fishflies appeared two or three weeks earlier in June (occasionally by the end of May) than the dobsonflies and reached their maximum population by the end of June, diminishing in numbers the early part of July and completely disappearing by the end of July. The peak of the dobsonfly abundance occurred in mid-July with rare individuals seen the first part of August. The sex-ratio of the dobsonflies at the bait traps indicated a slightly greater number of males, whereas that of the fishflies was approximately equal. At two light traps set up at Six Mile Creek, the ratio was almost 5:1 in favor of the male dobsonflies, whereas that of the fishflies still remained about equal.

In the present experimentation, the drops of the honey and water mixture were placed on the wire of the cages adjacent to the mouth after sclerotization

had been completed, or, two or three days later, fed directly to the insects, with the insect being held in one hand and the dropper in the other. The mandibles did not appear to function in feeding, while the maxillary and labial palpi, with maxilla and labia, worked energetically to bring the fluid to the opening between the large labrum and labium. In one instance, a female dobsonfly was seen at night, when greatest activity occurred, attempting to bite oak leaves (*Quercus alba* L.) placed in the cage. Two female fishflies were observed pulling apart lantana blossoms placed in the cage and also endeavoring to bite one another's wing tips. One female dobsonfly, no more than two hours after emergence, bit the thumb of the writer, so that blood flowed freely as from the cut of a knife. Three male dobsonflies, which had either fallen into or voluntarily entered the pans of water on the floor of the cages, appeared to drink the water at night by keeping the mandibles raised above the water (changed every day) and palpi below the water, while seemingly swimming with wings raised above the surface. The abdomens of both male and female were so soft and flexible that they dragged along the surface as the insects walked from place to place.

Specimens of both species lost portions of the tips of wings, tarsi, antennae and mandibles (male dobsonflies), possibly because of the restraint of the confinement for the most part, as specimens collected in nature seemed to generally possess these parts intact. Longevity of the dobsonflies, all of which were dead by June 23, ranged from four to thirteen days for the males and six to ten for the females, with an average of eight days for both sexes. Three days for the males and eight to ten days for the females had been previously reported by Davis (03:476). All the fishflies were dead by June 11 with an average longevity of six days. It was interesting to note that the latter insects died resting on their legs, whereas the majority of the dobsonflies died overturned on their backs.

On the afternoon of June 12, four cages (approximately 12 in. x 12 in. x 15 in., open on two sides and with wire mesh on three sides and top, and wood frame, ½ in. thick, 4 in. wide around one end and ½ in. wide at other points) were placed together so as to form a unit. An unmated isolated female which had emerged overnight and two males, one of which had emerged about three and one half hours previously (the smaller) were placed in the cages. Small pans of water and twigs of white oak, basswood (*Tilia americana* L.) and American elm (*Ulmus americana* L.), some forming crossbars, were scattered about the cages. The shades were drawn in the room to simulate darkness and a lantern was flashed on the cages periodically to observe the activity. Within a quarter hour, the larger male approached the female, resting vertically on the wire of a side of a cage and prodded her briefly with his mandibles, which were eventually laid over her wings at an angle almost perpendicular to the axis of the wings. This position was maintained for approximately twelve minutes, after which the smaller male approached the pair. Immediately a spectacular battle ensued; the two males fought ferociously with their mandibles, the larger one taking a defensive stand and attempting to chase the other away. The female was knocked down to the bottom of the cage and within about ten minutes, it was observed that

the mandibles of the larger male were broken. Forthwith the smaller male ran over to the female (again up on the side), and brought antennae and then mandibles into contact. At first the female seemed to resist all advances by moving away, but after another ten minutes remained quiescent, whereupon she was pushed around by the mandibles of the smaller male for a minute or two. These were placed over the wings of the female, as were those of the larger male previously, for approximately five minutes. Then the male removed his mandibles and keeping his head almost parallel with that of the female, though lower down in the cage at about the level of the caudal portion of her abdomen and about 5 cms. apart, he wriggled his soft abdomen for about one half minute with three to four series of several rapid quivers each. Then twisting his abdomen at about the junction of the thorax and abdomen at almost a right angle to his own and the thorax of the female, copulation took place, lasting about one half minute. Following this the male again placed his mandibles over the wings of the female and the two remained in that position during the next hour of observation. The defeated larger male did not appear to attempt to mate again on that night.

On the early morning of June 13, the smaller male still had his mandibles over the wings of the female; in the afternoon the two appeared to quickly mate again, after which the mandible-wing position was resumed. In the evening, the two separated and the abdomen of the female had become quite plump.

On June 14, the larger male was observed to assume the mandible-wing position while the smaller male remained inactive at the top of the cage and did not repel him. Although attempting several times to mate, the larger male was unsuccessful as he could not appear to get his abdomen under the wings of the female, even though once he was seen to crawl up her back for about three seconds. On June 15, the female was found hiding in the leaves below while the males were very active, and on June 16 and 17, all three appeared to be visibly weaker, although fed the water and honey solution. On June 18, the smaller male again assumed the mandible-wing position and even pushed the female around, whereas the larger male remained inactive. On June 20, the smaller male was found on his back with an antenna caught in the wire of the cage and was released. No further mating activity was observed and on June 22 the males died; the female succumbed approximately fifteen hours later. Hasty dissection of the female revealed eggs that appeared to be close to complete development.

A previous observation of the mating process was made on June 9, when two females (emerged June 8 and 9) and twelve males (emerged June 7 to 9) were placed in a large bee cage (approximately 60 in. high, 30 in. wide, 45 in. deep). Activity was observed to reach a high state after midnight, when the males flew back and forth. One female remained quiescent at the bottom of the cage, apparently injured during transmission to the cage; the other climbed up one side. A male approached the latter, prodded her briefly and assumed the mandible-wing position for approximately fifteen minutes. Then he raised the wings of the female with his mandibles for a brief instant and adopted a position similar to that already described (although with his head at more of

an angle); his abdomen jerked with the series of quivers and was bent upward to mate for approximately forty-five seconds. The mandible-wing position was again resumed. Each of three other males that approached was vigorously fought off with his mandibles. In about five minutes, both male and female had moved ten inches or so to another spot on the same side of the cage and appeared to attempt copulation again. After an hour, the first male departed and other males approached but were repulsed by the female, which walked or flew but refused to remain still. Eventually, the female disappeared into some white oak leaves in the cage and was found there the next night. Though she climbed up the side of the cage again, the other males did not come near. The second female remained motionless on the floor of the cage and died two days after being placed in the cage.

It was noticed that crossbars, though present in the form of the framework of the cages and twigs, were not used. Whether in nature the mating position is vertical, and not horizontal, is a matter of conjecture.

No spermatophore was observed in the dim light, although the possibility is not denied. Spermatophores have been noted for the closely related Sialidae of the Megaloptera by DuBois and Geigy (35:198, fig. 8b) and Khalifa (49:462, fig. 13) in the palaearctic *Sialis lutaria* (Linne) and by Killington (32:66) in the palaearctic *S. fuliginosa* Pictet. No mention of a spermatophore was made by Needham (01:549) in his observation of the mating of *Nigronia serricornis*, however. For the Neuroptera, definite spermatophores have been reported in certain palaearctic species as follows: *Sympherobius pygmaeus* (Rambur) of the Hemerobiidae by Killington (31:222); *Sisyra* of the Sisyridae by Withycombe (23:524); *Nathanica fulviceps* (Stephens) of the Chrysopidae by Killington (35:111); and *Osmylus chrysops* Linne of the Osmylidae by David (36:166) and *Osmylus* by Withycombe (23:517, pl. 38, fig. 11).

The placing of the mandibles of the male across the wings of the female for variable periods of time is apparently a unique characteristic of the mating of dobsonflies. The possible occurrence of sexually attractive stimuli is yet to be investigated. Geigy and DuBois (35:452, fig. 1) have demonstrated the possibility of scent glands on the costal and subcostal veins of the wings of the female and receptive organs (as *sensilla basiconica*) in the labrum of the male (ibid.: 454, fig. 2) of *Sialis lutaria*. At no time was the male observed to use his long mandibles to grasp the female as has been suggested (Riley, 77:126; 73:145; Walsh and Riley, 68:62). Instead they appeared to be used mainly to establish contact with the female, ward off competitors and for protection.

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The numbers in parentheses have the following significance: 1) new genus or genera described; 2) new species described; 3) data regarding biology; 4) key to genera; 5) key to species; 6) faunal list; 7) data on synonymy; 8) references; 9) discussion of classification and phylogeny; and 10) general reference, examined in part only.

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An Annotated Key to the Nearctic Males of Limnephilus (Trichoptera, Limnephilidae)

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Originally this paper was planned for some notes concerning species of *Limnephilus* from Utah. These were assembled by the junior author in the course of a survey of the caddisflies of that state. As the work progressed, it seemed advisable to bring up-to-date and include a key which the senior author has had in manuscript. There has been a need for some time for a key to the Nearctic species of this group, and it is hoped that this one will be of assistance in the identification of the North American forms. Reference is given in the key to existing illustrations for many species; for the remainder drawings are given in this paper.

We have been aided greatly by assistance from several workers. Mr. Fernand Schmid has convinced us of the value of regarding *Lenarchus* and *Philarctus* as genera, rather than as subgenera as was our original intention. Dr. Denning has graciously loaned us critical material, and many other friends have furnished valuable state records. The officers of the Museum of Comparative Zoology and the United States National Museum have placed at our disposal types and other material for study. To all these we wish to express our appreciation. The types of the new species described in this paper are in the collection of the Illinois Natural History Survey.

Status of Limnephilus

In the past there have been marked differences of opinion as to the definition and limitation of the genus *Limnephilus*. In 1874 McLachlan characterized the genus as "most untruly," and in the next year mentioned that closer acquaintance with it had not changed his opinion as to the difficulty of fixing its limitations. Many genera have been proposed to effect a subdivision of the genus, but a great many of them appear to be untenable.

The unit keyed in this paper comprises all the North American species which to our knowledge will resolve to *Limnephilus* in the key given by Ross (1944, p. 181). This unit includes species which would fall into fifteen or more genera that have been proposed by various authors. Due to limitations of both material and analysis, we are able to consider at the present time only those proposed genera which most obviously apply to the North American fauna. These are *Chaetotaulius* Kolenati, *Goniotaulius* Kolenati, *Desmotaulius* Kolenati, *Apolopsyche* Banks, *Algonquina* Banks, *Anabolina* Banks, *Colpotaulius* Kolenati, *Rheophylax* Sibley, *Astratodina* Mosely, *Anabolia* Stephens, *Clistoronia* Banks, *Philarctus* McLachlan, and *Lenarchus* Martynov.

McLachlan, in 1875, reduced to synonymy three of Kolenati's genera—*Chaetotaulius, Goniotaulius,* and *Desmotaulius.* These three genera, together with *Apolopsyche* and *Algonquina,* represent closely related although somewhat distinctive subdivisions of what may be called the main part of *Limnephilus.*

There is an interesting phyletic line within the genus in which a very gradual development may be traced from typical members with males having no sexual dimorphism and having the front basitarsus long, to an extreme of development in which the males have some differences in wing shape and venation, and distinctive characters of the front legs, notably a very short basitarsus. Representative of the base of this line is the European *L. affinis* Curtis, from which a fairly direct line may be traced through forms such as *perpusillus* Walker and *labus* Ross to the ends of the branch represented by *submonilifer* Walker and *secludens* Banks. Correlated with these male characters are changes in the female, in which the cerci become progressively more fused with the tenth tergite, this development reaching its extreme in *submonilifer,* in which the cerci are represented only by pad-like swellings. So well is this phylum documented by persisting forms that it is not feasible to make a division at the generic level at any place in it. This line includes the genotypes of *Anabolina, Colpotaulius, Rheophylax, Astratodina,* and undoubtedly others.

The genus *Anabolia* seems to be merely a subgroup of *Limnephilus* somewhat on the same level as *Chaetotaulius,* and not to be a good generic segregate. In North America it is represented by seven or eight species belonging to the *bimaculatus* complex.

The genus *Clistoronia* is also difficult to diagnose. The genotype, *magnificus* Banks, resembles in many respects species of *Limnephilus* such as *flavicollis* Banks and *santanus* Ross. From all three, *C. maculata* Banks and *formosa* Banks differ strikingly in female genitalia, which may indicate that their association with *magnificus* is based more on similarity of appearance than on relationships. Because of the affinities of the genotype, the species of *Clistoronia* are tentatively considered as belonging to *Limnephilus.*

Two genera of the *Limnephilus* complex seem to represent phylogenetic units definitely apart from the large aggregation of *Limnephilus* itself. These are *Philarctus* and *Lenarchus.*

Philarctus was described by McLachlan in 1880 with *P. bergrothi* McLachlan as genotype by monotypy. In general appearance it is remarkably like *Limnephilus janus* and allies but differs from this group and all other species of *Limnephilus* in its extremely distinctive male genitalia and in having a row of black preapical spines on the anterior face of the front femur. It also lacks the interocellar macrochaetae typical of most *Limnephilus.* The only North American species is *quaeris* (Milne), which is extremely close to *bergrothi* but differs in a few details from McLachlan's drawings. Until it is possible to compare Eurasian and North American material of these two species, it seems better to hold them as distinct.

Lenarchus was described by Martynov in 1915 with the inclusion of four named species and one unnamed species but with no designation of genotype. *Asynarchus productus* Morton was mentioned first, and first treated in detail, so we are hereby designating this species as the genotype of *Lenarchus*. The genus includes nine North American species. These species fall into several sub-groups which differ from each other very radically but which have in common the shape of the claspers, the broad ninth tergite, and the horizontal and dorsal position of the cerci. The clasper in particular is unique. Its attached basal portion is wide ventrally and narrows dorsally; the apical free part may be absent, but if present is a finger-like projection arising almost as an independent filament. In *Limnephilus lithus* Milne the basal portion of the clasper approaches this condition, fig. 24, but the apex of the clasper has a projection typical of *Limnephilus*. We have found no corresponding distinctive character to set off the females of *Lenarchus* from those of *Limnephilus*. In this sex the genitalia in particular are extremely varied in both genera, but further study may point out diagnostic differences. It is interesting that certain species of *Lenarchus*, such as *gravidus* Hagen, are remarkably similar in size and appearance to some of the larger *Limnephilus*.

Whether the group of species here placed in *Lenarchus* is a natural unit or is purely an artificial grouping is a problem which needs elucidation through a study of the world fauna of the entire complex.

The three genera of the complex here considered as valid may be separated as follows.

KEY TO GENERA

1. Front femur in both sexes with a row of 3 to 6 black spines on anterior face extending from middle to apex, in addition to similar spines at apex; male genitalia, fig. 1, with cerci forming a low, hairy cushion which is fused the ninth tergite and the blades of the tenth tergite to form a hood, below which project the platelike lateral pieces of the tenth tergite. Contains only one species, *quaeris* (Milne). Northern and Rocky Mts. ..... *Philarctus* McLachlan

   Front femur without preapical spines, having only 1 to 3 black spines at apex of anterior face; male genitalia with parts not fused in above fashion, figs. 2-25, cerci always distinct and tenth tergite never fused with ninth 2

2. Male genitalia, figs. 2-6, both with clasper forming a band along posterior edge of ninth sternite, the band wider ventrad, narrower dorsad, and often bearing a finger-like or almost threadlike dorsal angulation or process proceeding posteriad; and also with ninth tergite broad, usually forming a wide band with remainder of ninth segment ..... *Lenarchus* Martynov

   Male genitalia either with attached part of clasper broad dorsad and narrowing ventrad, or with dorsal band of ninth tergite reduced to a thin bridge, figs. 7-25 ..... *Limnephilus* Leach

Genus LENARCHUS Martynov

KEY TO MALES OF NEARCTIC SPECIES

1. A pair of sclerotized hornlike processes between posterior edge of ninth tergite and base of cerci (Ross 1938*a*, fig. 104); clasper not at all differentiated from ninth segment by a suture. Ont. ..... *keratus* Ross

No pair of horns at edge of ninth tergite; clasper usually well marked 2

2(1). Apex of ninth tergite bifid and projecting beyond cerci, fig. 2 3
Apex of ninth tergite either not bifid or not projecting over cerci, figs. 5, 6 6

3(2). Apical lobes of ninth tergite separated by nearly the width of the segment, each appearing fused with the cercus beneath; free part of clasper curving sharply dorsad, fig. 3. Mass. .....*crassus* Banks
Apical lobes of ninth tergite fairly close together and not fused with cerci; free part of clasper absent or projecting posteriad 4

4(3). Apex of ninth tergite narrow and divided into two sharp points; cercus massive, its posterior margin sclerotized and serrate; lobes of tenth tergite simple, stout, and upcurved; clasper without projecting apex; fig. 2. Syn.: *Clistoronia bifida* Ling. Ore., Wash., B. C. .....*rho* Milne
Apex of ninth tergite wide, with two points; cercus and lobes of tenth tergite each divided into a pair of processes 5

5(4). Clasper with a finger-like free apical portion angled posteriad; ninth segment with a wide solid bridge basad of projecting portion (Ross 1941*b*, fig. 88). Syn.: *L. taronus* Ross. Alaska, Siberia .....*expansus* Martynov
Clasper with no free dorsal portion; ninth segment with dorsal projecting plate extending nearly to base of segment (Ross 1938*b*, fig. 78). Newfoundland ..... *pulchellus* Banks

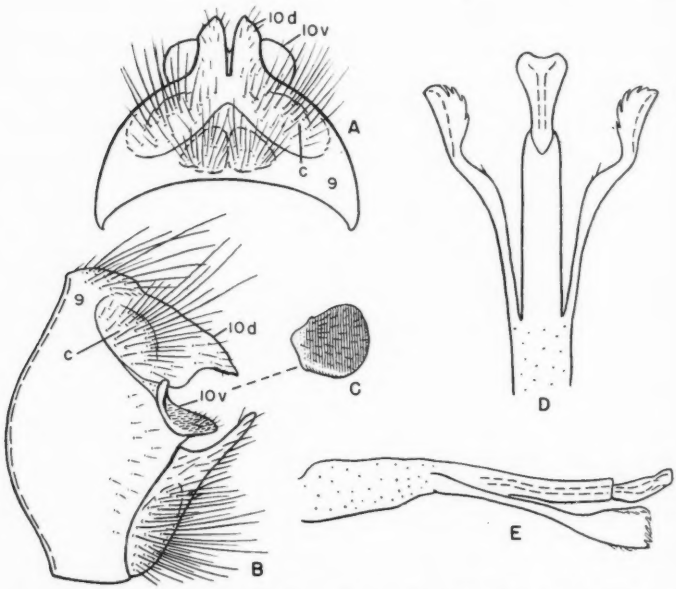


Fig. 1.—Male Genitalia of *Philarctus quaeris*. *A*, dorsal aspect; *B*, lateral aspect; *C*, dorsal aspect of ventral plate of tenth tergite; *D*, aedeagus, dorsal aspect; *E*, same, lateral aspect. *c*, cercus; 10*d*, dorsal portion of tenth tergite; 10*v*, ventral plate of tenth tergite.

6(2). Clasper with an elongate, dorsal, finger-like process; each lobe of tenth tergite having a mesal projection and a large lateral lobe, but the two arising from a common base, fig. 5 7

Clasper with no projecting portion; each lobe of tenth tergite apparently completely divided to form a mesal and a lateral sclerite, fig. 6 10

7(6). Cerci fused only at base, each with a long, posteriorly directed tooth mesad of lateral tooth, fig. 4. Ore. ..... *oreus* Milne

Cerci fused for half or more their mesal length, and without such a sharp tooth along posterior margin, fig. 5 8

8(7). Cerci fused for about half of their mesal length; tenth tergite lobe with lateral piece two-thirds length of mesal piece, this latter reaching only as far posteriad as cercus, fig. 5. Nev. ..... *rillus* Milne

Cerci fused for almost their entire mesal length; tenth tergite lobe with lateral piece only a third length of mesal piece, the latter extending much beyond cercus 9

9(8). Apico-mesal corner of cercus forming a blunt, up-curved lobe (Ross 1938*b*, fig. 75). Syn.: *L. rotundatus* Banks. Calif. ..... *gravidus* Hagen

Apico-mesal corner of cercus sloping downward (Ross 1938*b*, fig. 74). Syn.: *L. intermedius* Banks. Alaska, B. C. ..... *vastus* Hagen

10(6). Cerci separated by only a short and very narrow mesal cleft, fig. 6; tenth tergite lobes slender and tapering evenly to sharp apex ..... *brevipennis* (Banks)

Cerci separated by a deep, wide, rectangular cleft; tenth tergite round at base, with a short beaklike tip (Denning 1949*b*, fig. 9). Gt. Slave L., Can.; Wyo. ..... *fautini* Denning

LENARCHUS EXPANSUS Martynov

Lenarchus expansus Martynov, 1915. Ann. Mus. Zool. Ac. Sc., Leningrad, 19: 227. ♂, ♀. *Limnephilus taronus* Ross, 1941. Am. Ent. Soc. Trans. 67: 110. ♂, ♀. New synonymy.

Mr. Fernand Schmid has drawn our attention to the above synonymy. The types of *expansus* are from Jana and Kolyma Rivers in Northeastern Siberia, those of *taronus* from Pt. Barrow, Alaska. The three localities are not far apart. Martynov's drawings show clearly the diagnostic characters of the species.

Genus LIMNEPHILUS Leach

KEY TO MALES OF NEARCTIC SPECIES

1. Front basitarsus as long as or longer than succeeding segment 2
Front basitarsus not more than one-half length of succeeding segment 72

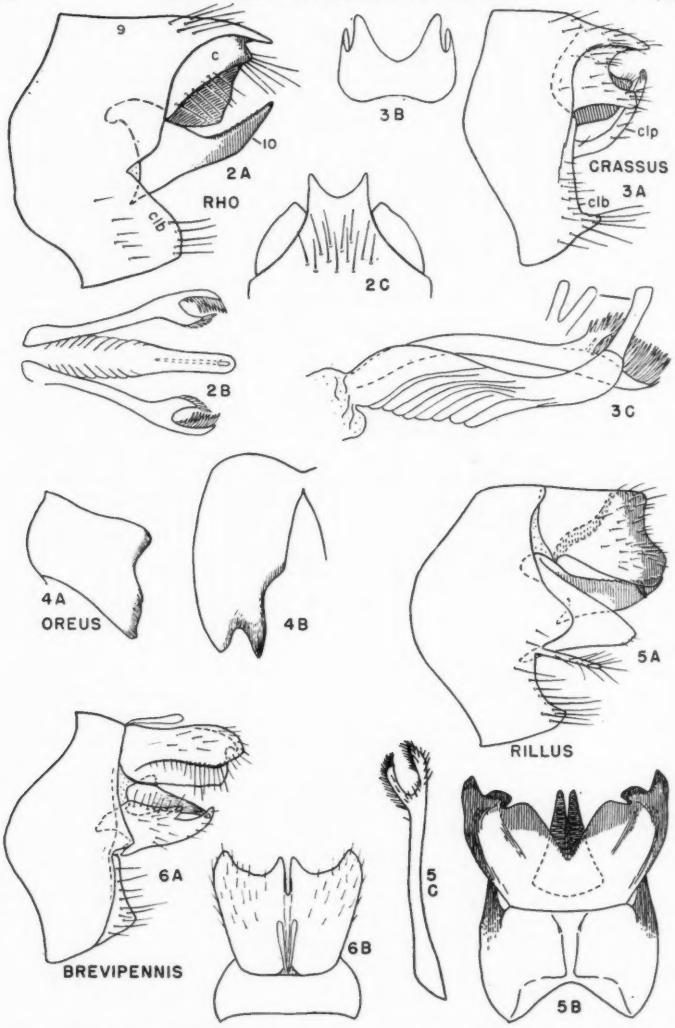
2(1). Front basitarsus distinctly longer than (usually one and one-half times) second segment 3
Front basitarsus subequal in length to second segment 67

3(2). Apex of eighth tergite produced into a pair of slender, sharp processes lying close together and extending considerably beyond body of segment (Leonard & Leonard 1949, figs. 1-2). Mich. ..... *rossi* Leonard & Leonard

Apex of eighth tergite either completely undivided, or lobes wide and round .. 4

4(3). Clasper held in a nearly transverse position, and with a wide, dentate posterior face, fig. 7*c* 5

Clasper with posterior face either narrow or only bifid, i.e., with only two projections 6



Figs. 2-6.—Male Genitalia of *Lenarchus*. 2, *L. rho* (type): *A*, lateral aspect; *B*, aedeagus, ventral aspect; *C*, dorsal aspect. 3, *L. crassus* (type): *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus, lateral aspect. 4, *L. oreus* (type): *A*, lateral aspect of cercus; *B*, dorsal aspect of cercus. 5, *L. rillus* (type): *A*, lateral aspect; *B*, dorsal aspect; *C*, lateral arm of aedeagus. 6, *L. brevipennis*: *A*, lateral aspect; *B*, dorsal aspect. *c*, cercus; *clb*, clasper base; *clp*, apical process of clasper.

5(4). Tips of lateral arms of aedeagus crossing above aedeagus; lobes of tenth tergite extending posteriad same distance as cercus, fig. 7. Northern, subarctic. Syn.: *L. moselyi* Kimmins & Denning 1951, figs. 12, 13 ..... *kennicotti* Ban's

Tips of lateral arms of aedeagus branched but not crossing above aedeagus; lobes of tenth tergite extending posteriad beyond cercus (Denning 1949*a*, fig. 4). Ore. ..... *sylviae* Denning

6(4). Posterior margin of cercus incised about half its length, at least as much as in figs. 10, 11 7

Posterior margin not incised more than shown in fig. 12 9

7(6). Cercus bladelike, without a mesal lobe, and with lower arm longer than upper; lobes of tenth tergite more massive (Ross 1944, fig. 653). Syn.: *L. elegans* Mosely. Northern N. A., Greenland, Japan ..... *ornatus* Banks

Cercus almost pyramidal, with posterior aspect nearly triangular because of a large, angulate or truncate mesal projection, figs. 11*B*, 12*B* 8

8(7). Both arms of cercus curving ventral; tenth tergite pointed and curved dorsad, its base situated ventrad of the lower level of the cercus; lateral arms of aedeagus undivided at tip, fig. 10. Alaska, B. C. ..... *flavicollis* (Banks)

Both arms of cercus projecting straight posteriad; tenth tergite parallel-sided, round at apex, and curving slightly ventrad, fig. 11; lateral arms of aedeagus divided into a long dorsal and a shorter apical arm (Denning 1941, fig. 5; Banks 1943, figs. 40, 43, 49). Syn.: *Clistoronia magnus* Banks, *L. caroli* Denning. B. C., Ore. ..... *magnificus* (Banks)

9(6). Lateral appendages of aedeagus simple, rodlike, angled, and crossed over aedeagus (Ross 1938*b*, fig. 76). Free part of clasper large, platelike, and facing chiefly posteriad; cercus curved posteriad. Colo., Utah, Wyo. ..... *coloradensis* (Banks)

Lateral appendages not crossing over aedeagus, or absent 10

10(9). Tenth tergite knobbed or broad at apex, and large, dwarfing cerci in size, fig. 14 11

Tenth tergite smaller or with apex small 12

11(10). Cercus slender and elongate, curving mesad at tip, mesal surface concave; clasper elongate and filiform (Ross 1938*b*, fig. 81). Calif., Nev., Ore. ..... *morrisoni* Banks

Cercus short and with a massive, sharp inner projection; clasper short, fig. 14 ..... *castor* n. sp.

12(10). Lateral arms of aedeagus with tubular base merging imperceptibly with a long, membranous, extensile arm surmounted by a large clump of spicules, as in fig. 14C 13

Lateral arms of aedeagus either short, fig. 9C, slender, or almost all sclerotized and with different armature 19

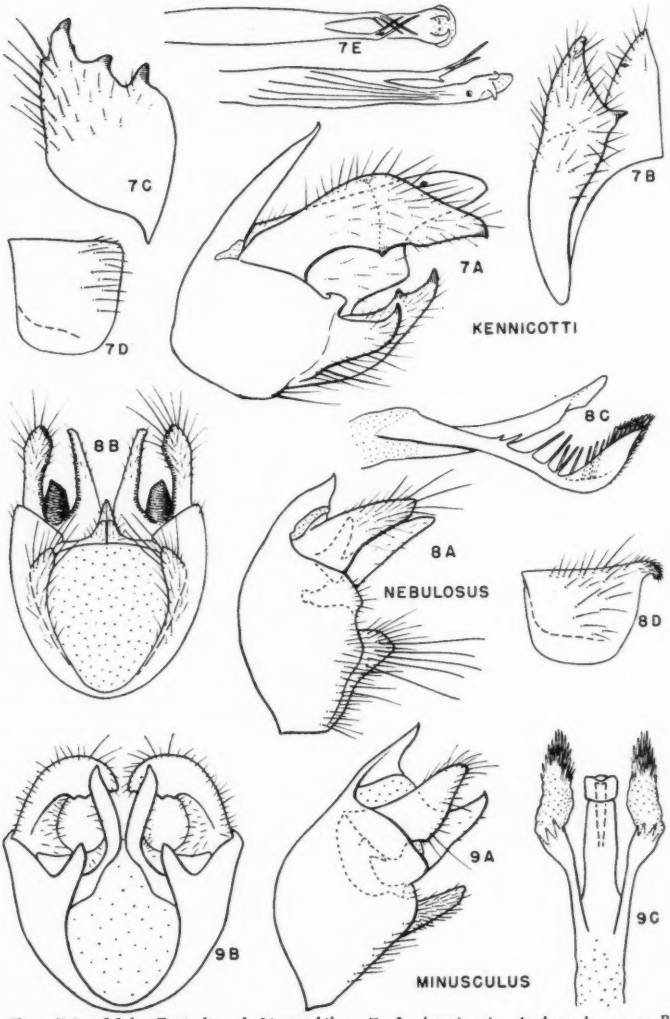
13(12). Clasper with lateral aspect entirely concave, and apex arcuately emarginate to form a sharp point at each corner (Mosely 1939, figs. 97, 98). North Europe, Iceland, Greenland ..... *griseus* (Linnaeus)

Clasper with lateral margin convex 14

14(13). Dorsal portion of clasper large and stocky (Ross 1944, fig. 657). Body and wings almost uniformly straw color. Northern and transcontinental ..... *hyalinus* Hagen

Dorsal portion of clasper small, forming a narrow, fairly sharp triangle. Body and wings with dark mottling 15

15(14). Cercus with mesal sclerotized ornamentation produced as mesal points only at apical margin 16



Figs. 7-9.—Male Genitalia of *Limnephilus*. 7, *L. kennicotti: A*, lateral aspect; *B*, dorsal aspect of cercus and lobe of tenth tergite; *C*, clasper, posterior aspect; *D*, eighth tergite, lateral aspect; *E*, *aedeagus*, dorsal and lateral aspects. 8, *L. nebulosus: A*, lateral aspect; *B*, postero-ventral aspect; *C*, aedeagus, lateral aspect; *D*, eighth tergite, lateral aspect. 9, *L. minusculus: A*, lateral aspect; *B*, postero-ventral aspect; *C*, aedeagus, dorsal aspect.

Cercus with points running from apex toward base, or with a large projection at middle or base, figs. 15, 16 17

16(15). Tenth tergite with base enlarged and almost as large as cercus; cercus broad and low from lateral view (Ross 1941*a*, fig. 7). Ore. .....*fagus* Ross

Tenth tergite with base small; cercus higher and thinner from lateral view (Betten & Mosely 1940, fig. 58; Ross 1944, fig. 655). Syn.: *despecus* Walker, *multifarius* Walker, *perforatus* Walker, *eminens* Betten. Alaska and B. C. to N. Y. .....*sericeus* (Say)

17(15). Cercus with sclerotized teeth running from base to apex; lateral aspect of cercus deep (Ross 1941*b*, fig. 87). Ariz., Wyo. .....*arizona* Ross

Cercus with a large, sharp mesal projection at middle or base, figs. 15, 16; lateral aspect of cercus shallow 18

18(17). Cercus with mesal point near base, fig. 15 (also Ross 1938*b*, fig. 71). Colo., Wyo. .....*abbreviatus* Banks

Cercus with mesal point near middle, fig. 16 (also Denning 1949*a*, fig. 5). Wyo. .....*saltus* Denning

19(12). Both cercus and clasper large, but tenth tergite minute, fig. 13. Syn.: *L. forcipatus* Banks. Holarctic, northern .....*nigriceps* Zetterstedt

Either cercus or clasper much smaller, or tenth tergite larger 20

20(19). Clasper stocky and short, the apex incised to make a clawlike apex 21

Clasper with apex either longer, fig. 21, or not incised more than in fig. 17 27

21(20). Tenth tergite button-like, flat, with no projecting blades; cercus deep, with a sharp point near ventral margin of posterior edge (Ross 1938*b*, fig. 65). Syn.: *Anabolia modesta* Hagen, *Stenophylax fusorius* McLachlan, *Asynarchus simplex* Banks. Holarctic, northern .....*lapponicus* (Zetterstedt)

Tenth tergite with projecting mesal blades which may be small; cercus with posterior projections further dorsad or with none 22

22(21). Postero-ventral corner of cercus set off by a sharp, oblique crease from remainder 23

Postero-ventral corner of cercus flowing evenly and convexly with remainder 25

23(22). Postero-dorsal corner of cercus developed into a sclerotized mesal lobe similar to the one below it (Ross 1941*a*, fig. 9). Alberta .....*aldinus* Ross

Postero-dorsal corner of cercus blake-like and not developed into a sclerotized lobe 24

24(23). Lower apico-mesal lobe of cercus slender and arising near dorsum (Ross 1950, fig. 18). Ont. to Labrador .....*curtus* (Banks)

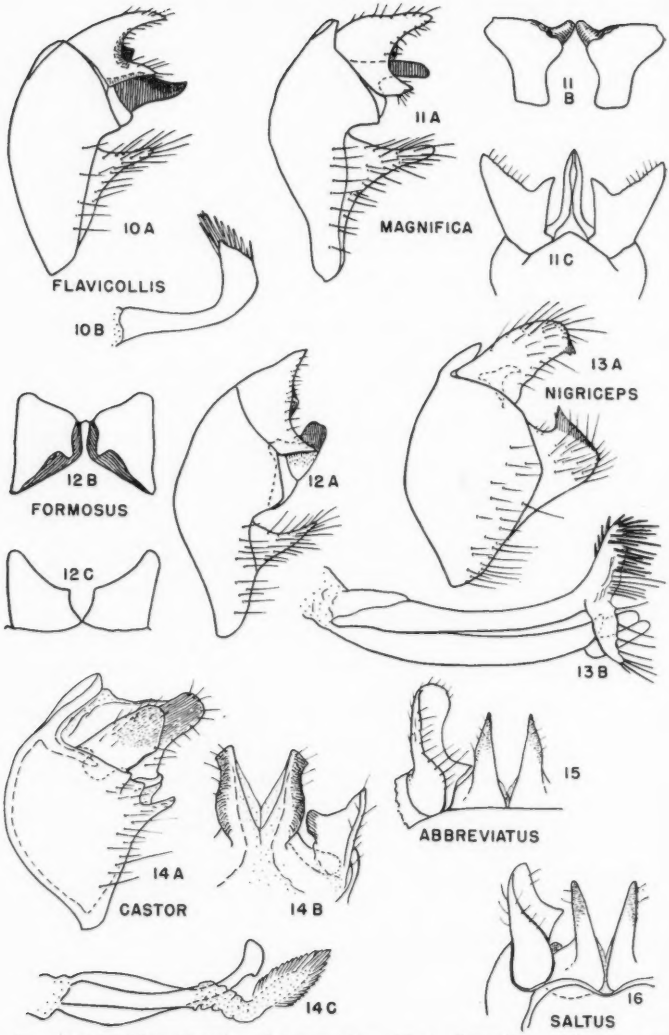
Lower apico-mesal lobe of cercus stouter and arising near midpoint (Ross 1950, fig. 19). Syn.: *L. conerus* Ross. Ont. to Wyo. and Alaska ....*batchewana* Denning

25(22). Cercus with posterior margin without projections; lobes of tenth tergite extremely short and with apex truncate (Schmid 1950, figs. 5-8). B. C. .....*cinnamoneus* Schmid

Cercus with a projection or angulation from posterior margin; lobes of tenth tergite moderately long, pointed or narrow at apex 26

26(25). Postero-dorsal corner of cercus composed of a sclerotized pointed projection below the apex (Ross 1938*b*, fig. 68). Colo., Wyo. .....*nigriculus* (Banks)

Postero-dorsal corner of cercus composed of a somewhat angulate shoulder ventrad of the sclerotized, pointed projection below the apex (Ross 1950, fig. 20). Alaska .....*emarginatus* (Banks)



Figs. 10-16.—Male Genitalia of *Limnephilus*. 10, *L. flavicollis*: *A*, lateral aspect; *B*, lateral arm of aedeagus. 11, *L. magnifica* (type): *A*, lateral aspect; *B*, posterior aspect of cerci; *C*, dorsal aspect. 12, *L. formosus* (type): *A*, lateral aspect; *B*, cerci, posterior aspect; *C*, cerci, dorsal aspect. 13, *L. nigriceps* (type of *forcipata*): *A*, lateral aspect; *B*, aedeagus, lateral aspect. 14, *L. castor*: *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus, lateral aspect. 15, *L. abbreviatus*, dorsal aspect. 16, *L. saltus* (type), dorsal aspect.

27(20). Lateral arm of aedeagus with end almost T-shaped; tenth tergite curving declivously to emerge below the cercus as a blunt point, fig. 17 ....*circopa* n. sp.
Lateral arm not T-shaped, or tenth tergite not sinuate in this manner 28

28(27). Clasper small and triangular, bearing on the baso-mesal portion a long, smooth, threadlike style, fig. 19. Alaska, B. C., Wash., Ore. ....*pacificus* Banks
Clasper without a long, inner style, at most with a heavily sclerotized spur 29

29(28). Cercus and tenth tergite long and bladelike, projecting chiefly posteriad, margins of cerci roughly subparallel, figs. 18, 19, 22 30
Either cerci or tenth tergite different 36

30(29). Clasper forming an irregular, short plate bearing a few or several long spines, this apical portion sometimes with ventral corner angular 31
Clasper forming a definite finger-like, ovate, or triangular lobe 35

31(30). Cercus shorter than dorsal lobes of tenth tergite; ventral lobes of tenth tergite large, padlike, and sclerotized, from lateral view appearing as truncate projections (Ross 1949, fig. 1). Ore. .....*lopho* Ross
Cercus longer than dorsal lobes of tenth tergite; ventral lobes of tenth tergite small or undeveloped 32

32(31). Apex of clasper with a large postero-ventral shoulder, bearing a cluster of a dozen or more, equally long, brown setae (Ross 1938*b*, fig. 84). N. Mex., Utah, Wyo. .....*cockerelli* Banks
Apex of clasper with a smaller ventral shoulder, but bearing on this region a number of short setae and 2 or 3 very long black ones 33

33(32). Lateral aspect of cercus broad; lateral arm of aedeagus with a broad lobe at apical bend, apex appearing bulbous (Ross 1938*b*, fig. 83). Colo. to Newfld. .....*moestus* Banks
Lateral aspect of cercus narrow; lateral arm of aedeagus narrow and angled sharply dorsad 34

34(33). Lobes of tenth tergite subequal in length to cercus (Ross 1938*b*, fig. 82). Syn.: *aequalis* Banks. Alaska, B. C., Wash., Ore. .....*harrimani* Banks
Lobes of tenth tergite reaching only midway between mesal shoulder and apex of cercus (Denning 1948*b*, fig. 6). Wyo. .....*gioia* Denning

35(30). Clasper small and papillate, bearing a few very long setae, fig. 18 .....*alconura* n. sp.
Clasper larger or more elongate 36

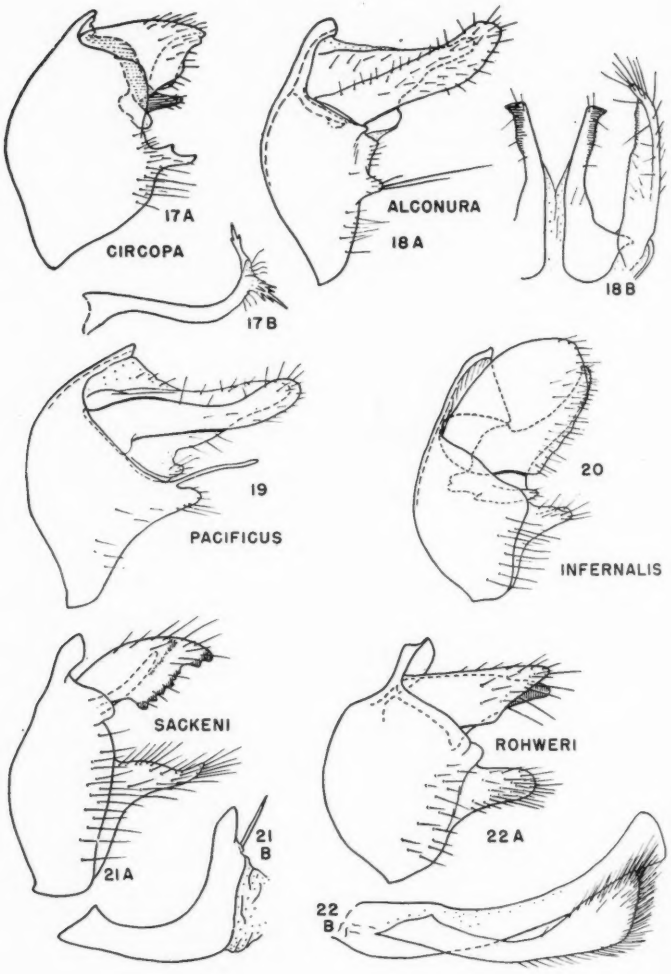
36(29, 35). Tenth tergite slender, long, and arched in middle higher than cercus (Ross 1944, fig. 940). B. C., Wash., Ore. .....*nogus* Ross
Tenth tergite not arched in middle higher than cerci, although the apex may reach above cercus 37

37(36). Eighth tergite produced into postero-mesal lobe usually covered with short, black or yellow setae, fig. 8*D* 38
Eighth tergite simple, fig. 7*D*, neither produced into a lobe nor with an apical patch of black setae 57

38(37). Posterior edge of cercus flattened and definitely flange-like, at right angles to lateral margin and bearing definite sclerotized points on mesal edge of flange 39
Posterior edge of cercus sharp or rounded in cross section, not flanged; if sclerotized points are present they arise from the edge of the cercus 41

39(38). Flange of cercus bearing sclerotized points only dorsad, fig. 9; tenth tergite with apex pointed .....*minusculus* (Banks)
Flange of cercus with sclerotized points both dorsad and ventrad 40

40(39). Clasper stocky and wide (Ross 1938*a*, fig. 107). Utah .....*thorus* Ross
Clasper more slender (Ross 1938*b*, fig. 80). Syn.: *congener* McLachlan,

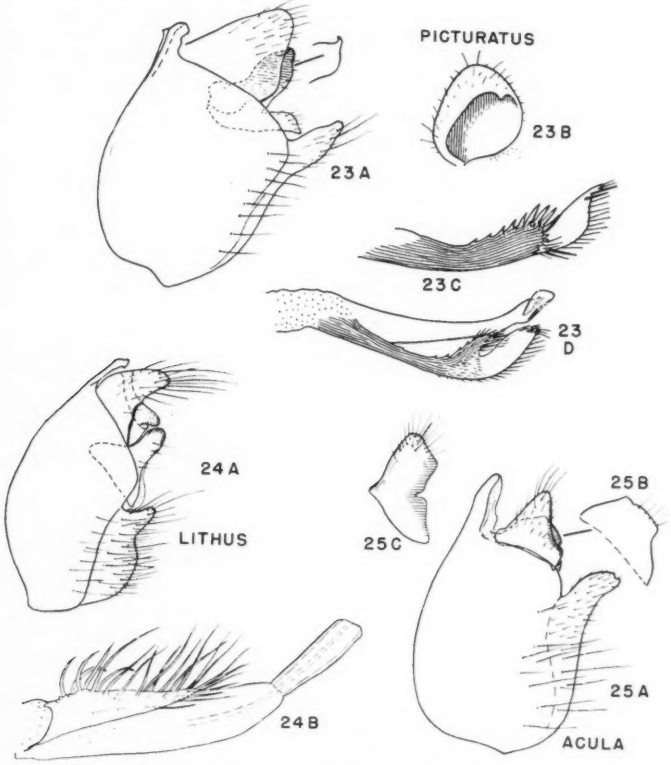


Figs. 17-22.—Male Genitalia of *Limnephilus*. 17, *L. circopa*: *A*, lateral aspect; *B*, lateral arm of aedeagus. 18, *L. alconura*: *A*, lateral aspect; *B*, dorsal aspect. 19, *L. pacificus*, lateral aspect. 20, *L. infernalis*, lateral aspect. 21, *L. sackeni* (type): *A*, lateral aspect; *B*, base of lateral arm of aedeagus. 22, *L. rohweri* (type): *A*, lateral aspect; *B*, aedeagus, lateral aspect.

?oslari Banks, *?flavostellus* Banks, *luteolus* Banks, *tersus* Betten. Holarctic
..... *externus* Hagen

41(38). Cercus shorter than high and without inner teeth 42
Cercus either longer than high, fig. 22, or with teeth on mesal face, or large and ovate, fig. 20 43

42(41). Cercus and clasper about equal in size, cercus squat and rectangular; tenth tergite sharp, slender, and long (Ross 1938*b*, fig. 56). N. W. Terr., Can.
..... *argenteus* Banks
Cercus much larger than clasper, elongate, and curving mesad at apex, the apexes of the two nearly meeting; tenth tergite larger (Denning 1942, fig. 2). Minn. ..... *acrocurvus* Denning



Figs. 23-25.—Male Genitalia of *Limnephilus*. 23, *L. picturatus*: *A*, lateral aspect; *B*, inner aspect of cercus; *C*, lateral arm of aedeagus, specimen from Colorado; *D*, same, specimen from Manitoba. 24, *L. lithus*: *A*, lateral aspect; *B*, aedeagus, lateral aspect. 25, *L. acula*: *A*, lateral aspect; *B*, tenth tergite, lateral aspect; *C*, cercus, posterior aspect.

43(41). Cercus with a large, single basal spur on mesal face (Ross 1938*b*, fig. 60). B. C., Wash., Ore. ..... *occidentalis* Banks
Cercus without a spur, or with only sclerotized lumps at base of mesal face 44

44(43). Cercus with a nearly straight caudo-ventral margin bearing a row of sclerotized dentations (sometimes small) scattered along its length, fig. 21 45
Caudo-ventral margin of cercus either definitely not straight or without a row of dentations 52

45(44). Cercus very large and ovate, tenth tergite minute; clasper short (Betten & Mosely 1940, fig. 66; Ross 1944, fig. 654). Syn.: *L. combinatus* Walker. Holarctic ..... *rhombicus* (Linnaeus)
Tenth tergite longer and larger in proportion to cercus 46

46(45). Posterior margin of cercus sloping obliquely antero-dorsal, that is, ventral margin extending much more posterad than dorsal margin (Betten & Mosely 1940, fig. 65; Ross 1944, fig. 658). Syn.: *L. subguttatus* Walker. Northcentral and northeastern, and B. C. ..... *indivisus* Walker
Posterior margin of cercus either perpendicular or its dorsal corner sloping posterad 47

47(46). Cercus with a long exposed ventral margin which is at least as long as posterior margin 48
Cercus with exposed ventral margin shorter than posterior margin, fig. 21, in some species very short and inconspicuous 49

48(47). Tenth tergite turned up at apex (Ross 1938*b*, fig. 72). N. W. Terr., Can. ..... *elongatus* Banks
Tenth tergite curved down at apex (Ross 1938*b*, fig. 73). Syn.: *L. macgillivrayi* Banks, *L. americanus* Banks. Northeast, west to Idaho and Colo. ..... *sublunatus* Provancher

49(47). Lobes of tenth tergites with very narrow finger-like lateral aspect, fig. 21 ..... *sackeni* Banks
Lobes of tenth tergite with wider lateral aspect 50

50(49). Cercus scarcely projecting posterad beyond outline of segment; clasper more nearly trianguloid than finger-like (Ross 1938*b*, fig. 69). N. W. Terr., Can. ..... *hageni* Banks
Cercus projecting markedly beyond outline of segment; clasper with projecting portion slender and finger-like 51

51(50). Lobes of tenth tergite projecting beyond cercus; cercus with posterior margin perpendicular (Betten & Mosely 1940, fig. 64). Syn.: *L. adustus* Banks ..... *partitus* Walker
Cercus projecting beyond lobes of tenth tergite, and with an oblique slope posterad (Ross 1938*b*, fig. 70). Alberta ..... *sansoni* Banks

52(44). Cercus with the disto-ventral corner armed with a small group of dentations and with the mesal face bearing a row of dentations down the middle (Ross 1941*b*, fig. 84). Ore. ..... *ectus* Ross
Cercus either without the disto-ventral group of dentations or without the mesal row of dentations 53

53(52). Cercus very large and earlike, fig. 20 ..... *infernalis* Banks
Cercus smaller, usually of different shape 54

54(53). Each lobe of tenth tergite with a dorso-lateral, dark lobe at base, fig. 8. Syn.: *L. femoralis* Kirby, *L. stipatus* Walker. Subarctic, Ont. ..... *nebulosus* Kirby
Tenth tergite without a dorso-lateral lobe 55

55(54). Cercus elongate and linear, roughly paralleling tenth tergite in both position and size, fig. 22 ..... *rohweri* Banks
Cercus ovate or triangular, tenth tergite much smaller and the two not coinciding at all in outline 56

56(55). Cercus triangular, tenth tergite straight (Betten & Mosely 1940, fig. 67). Ont. ..... *extractus* Walker

Cercus somewhat ovoid, tenth tergite curved ventrad (Ross 1938*b*, fig. 61). Syn.: *Apolopsyche pallidus* Banks, *L. roberti* Banks. Man., Que. ..... *parvulus* (Banks)

57(37). Clasper ending in a heavily sclerotized, shiny, pointed spike 58

Clasper ending in a flat or concave process 59

58(57). Cercus nearly as long as depth of ninth segment; tenth tergite and clasper proportionately long (Ross 1944, fig. 660). Syn.: *L. longicercus* Denning. Ill., Minn. ..... *sordidus* Hagen

Cercus much shorter, its length little more than half depth of ninth segment, and tenth tergite and clasper proportionately short (Betten & Mosely 1940, fig. 71; Ross 1944, fig. 661). Northern, transcontinental ..... *bimaculatus* Walker

59(57). Cercus with postero-dorsal angle produced into a short, posterior truncate lobe; clasper with apex incised dorsad to form a pair of sclerotized points (Betten & Mosely 1940, fig. 56; Ross 1944, fig. 656). Northern, transcontinental ..... *consocius* Walker

Cercus without dorsal projection, clasper without emargination 60

60(59). Cercus short, deep, and massive, its posterior aspect rhomboidal, its postero-margin evenly arcuate; lateral aspect of ninth segment very narrow, similar to fig. 11 61

Cercus either longer or its posterior margin not arcuate; lateral aspect of ninth segment usually wide, often massive, fig. 23 62

61(60). Ventral point of cercus extending as far posterad as dorsal point (Ross 1938*b*, fig. 46; Banks 1943, fig. 48). Utah ..... *formosa* Banks

Ventral point of cercus not extending nearly as far posterad as dorsal point (Banks 1943, fig. 47). Ariz., N. M. ..... *maculata* (Banks)

62(60). Lobes of tenth tergite high and narrow, as are the cerci, projecting a considerable distance above the dorsum of the ninth segment (Schmid 1950, figs. 1-4). B. C. ..... *insularis* (Schmid)

Lobes of tenth tergite and cerci either not high or not narrow 63

63(62). Cercus with posterior margin shelflike, at right angles to lateral margin, and bearing dorsad a large mesal tooth projecting from this shelf; base of tenth tergite projecting posterad as much as the lobes, fig. 23. Syn.: *L. exulans* McLachlan, *L. clausus* Banks, *L. kincaidi* Banks. Northern and Holarctic ..... *picturatus* McLachlan

Cercus leaflike, with normal thin posterior edge; base of tenth tergite not produced as a free posterior lobe 64

64(63). Lateral arm of aedeagus ending in a long, whiplike, clavate dorsal filament; clasper massive 65

Lateral arm of aedeagus ending in a curved or angled flap which is not clavate; clasper slender or small 66

65(64). Cercus short, trianguloid, and irregular (Ross 1938*b*, fig. 66). Labrador ..... *mutatus* Hagen

Cercus longer and rectangular, the posterior margin nearly straight (Ross 1938*b*, fig. 67). Syn.: *Stenophylax pacificus* Banks (Preoccupied). Wash., Idaho ..... *nepus* Ross

66(64). Lobes of tenth tergite with lateral aspect narrow, arising near posterior corner of cercus and curving sharply dorsad just beyond it (Ross 1949, fig. 2). Ore. ..... *santanus* Ross

Lobes of tenth tergite with broad, large lateral expanse, arising near base of cercus and projecting straight posterad far beyond it (Leonard and Leonard

1949, figs. 1, 2, 4-6). Que., Mich., Minn., N. Y., Ont., Man. ..... *ozburni* (Milne)

67(2). Lobes of tenth tergite produced into a sharp, recurved apical tip; cercus with only a single, small tooth at apex 68
Lobes of tenth tergite low and without a sharp tip, fig. 25; cercus with entire apical margin flange-like with apex and base of flange lobate or toothed 69

68(67). Cercus with a sclerotized mesal point on apico-dorsal corner (Betten & Mosely 1940, fig. 70; Ross 1938*a*, fig. 105). Syn.: *Colpotaulius rhaeus* Milne, *L. merinthus* Ross. Ont. to Colo. ..... *perpusillus* Walker
Cercus without a point on apico-dorsal corner (Ross 1941*b*, fig. 86). Calif., Ore. ..... *lunonus* Ross

69(67). Clasper triangular and massive (Ross 1938*a*, fig. 103). Calif. ..... *acnestus* Ross
Clasper finger-like and less massive 70

70(69). Apico-mesal corner of cercus extending in silhouette as a sharp point beyond body of cercus (Ross 1938*b*, fig. 79). Ariz., Colo. ..... *diversus* Banks
Apico-mesal corner of cercus forming a flush flange not extending in silhouette beyond body of cercus 71

71(70). Cercus with ventral margin nearly as long as dorsal margin, and posterior margin incised; and with mesal emargination of its posterior aspect; clasper straight (Denning 1948*a*, fig. 4). Syn.: *L. utahensis* Denning. Calif., Utah ..... *productus* Banks
Cercus with ventral margin very short and posterior margin almost straight, and with mesal emargination of posterior aspect very narrow; clasper curved at apex, fig. 25 ..... *acula* n. sp.

72(1). Meso-basal portion of cercus produced caudad of lateral portion into a finger-like, black-tipped, projection and appressed to similarly shaped lobe of tenth tergite, fig. 24. S. D., Tex. ..... *lithus* (Milne)
Meso-basal portion of cercus not produced into a long lobe 73

73(72). Clasper forming a shallow sclerite extending along posterior margin of ninth segment 74
Clasper produced conspicuously into a triangular or thumb-like projection 76

74(73). Lateral arms of aedeagus short and semi-membranous, appressed to base of main stem (Ross 1938*b*, fig. 63). Sask. to Utah and B. C. ..... *secludens* Banks
Lateral arms of aedeagus sclerotized 75

75(74). Lateral arms of aedeagus short and bent at a sharp angle not reaching apex of main stem (Ross 1941*a*, fig. 8). N. B. ..... *ademus* Ross
Lateral arms of aedeagus long, extending almost to apex of main stem (Ross 1938*b*, fig. 62). Colo. ..... *tarsalis* Banks

76(73). Eighth tergite with a meso-apical patch of short, dark setae 77
Eighth tergite simple, with only a few scattered setae 82

77(76). Aedeagus without lateral arms the shaft forming a heavily sclerotized, upturned, dorsally concave structure (Ross 1950, fig. 22). Tex. ..... *adapus* Ross
Aedeagus with a pair of lateral arms; shaft otherwise 78

78(77). Posterior margin of cercus shelf-like, heavily sclerotized and black; cercus and tenth tergite compact (Denning 1941, fig. 4). Me., Minn., Que. ..... *canadensis* Banks
Posterior margin of cercus blade-like or at most enlarged only slightly 79

79(78). Clasper shorter than deep; lobes of tenth tergite not produced into long, dorsal process 80
Clasper longer than deep; lobes of tenth tergite produced into a long dorsal process 81

80(79). Cercus triangular, small and scarcely surpassing clasper in lateral area (Ross 1944, fig. 941; 1949, fig. 3) Calif., Tex. ..... *frijole* Ross

Cercus more or less rhomboidal, much larger than clasper (Ross 1938*c*, fig. 11). Calif., Ore., Wash. ..... *aretto* Ross

81(79). Lateral lobes of aedeagus round and filiform, almost seta-like (Ross 1938*b*, fig. 57). Calif., Colo., Ore., Utah ..... *spinatus* Banks

Lateral lobes of aedeagus flattened and enlarged into a curved, flat brush at apex (Ross 1941*b*, fig. 85). Colo., Alberta, Sask. ..... *labus* Ross

82(76). Lateral arms of aedeagus long and threadlike 83

Lateral arms of aedeagus thick at base or angulate near apex 84

83(82). Lateral arms of aedeagus of even thickness throughout and bearing small hairs at tip; clasper short and thick; tenth tergite with only a small dorsal projection (Ross 1944, fig. 652). Syn.: *L. pudicus* Hagen. Northeastern ..... *submonilifer* Walker

Lateral arms thicker for basal half; claspers elongate and finger-like; tenth tergite with large dorsal projection (Ross 1938*b*, fig. 58). Ariz., Calif. ..... *assimilis* (Banks)

84(82). Lateral arms of aedeagus thick and toothed at base; cercus short, with an apico-dorsal spur (Ross 1938*a*, fig. 106). Okla., Utah ..... *taloga* Ross

Lateral arms of aedeagus of more even thickness throughout and angulate near apex; cercus fairly long with preapical dorsal spurs (Ross 1938*b*, fig. 59). Syn.: *Colpotaulius minusculus* Banks (preoccupied). Colo., Sask. ..... *janus* Ross

LIMNEPHILUS MAGNIFICUS (Banks)

Halesus magnifica Banks, 1899. Amer. Ent. Soc. Trans. 25: 209. *Clistoronia magnus* Banks, 1916. Can. Ent. 48: 119. Misspelling. *Anabolia caroli* Denning, 1941. Ent. Soc. Amer. Ann. 34: 196. New Synonymy.

This is a large and showy species whose range extends from Oregon to central British Columbia and western Alberta. There is some variation in the proportions of the cercus, one extreme being the condition shown in fig. 11 (drawn from the type of *magnificus*, from Olympia, Wash.), another is that shown in Denning's illustrations of *caroli* (loc. cit., fig. 5) from Mt. Robson, B. C. A point of confusion which frequently arises with this group concerns the orientation of the cerci. When dry and retracted they often appear flat across the top, from posterior view; when cleared in KOH they tend to flare so that the lateral angle is much higher than the mesal.

In my list of the Nearctic caddisflies (Ross 1944), this species, together with *formosa* (Bks.) and *maculatus* (Bks.), was placed in *Clistoronia*. Since adequate diagnostic differences other than type of genitalia have not been discovered, and since the monophyly of this complex is in serious doubt, it is proposed to consider these species as forming groups within the genus *Limnephilus*.

Limnephilus castor n. sp.

The general conformation of the genitalia, especially an almost exact duplication of the distinctive aedeagus, indicates that this is a sister species with *morrisoni* Banks. In *castor*, fig. 14, the cercus is short, with an oblique apex and a sclerotized, broad, mesal projection, and the clasper is very short. In *morrisoni* the cercus is elongate and pointed, and has no mesal projection, and the clasper is also elongate and very slender.

Male.—Length from tip of head to apex of folded wings, 16 mm. Color

yellowish brown, the leg spines darker; front wings with oblique light areas forming an irregular series between R_5 and Cu_1, this pattern resembling that of the *externus* group. Head with a macrochaeta before, behind, and mesad of each lateral ocellus. Mesonotal warts each consisting of a linear area bearing about five macrochaeta. Front basitarsus one and one-half times length of second segment. Eighth tergite of abdomen with a pair of apical cushion-like areas covered with a close brush of short, brown spicules.

Genitalia as in fig. 14. Ninth segment relatively robust and long across the middle, dorsally forming a high, narrow bridge. Clasper fusing imperceptibly with ninth segment, the projecting free portion short, narrow, and finger-like. Cercus only two-thirds as long as tenth tergite, its lateral aspect wide and parallel-sided, its apex oblique; from dorsal view, fig. 14*B*, is seen a mesal projection coming from the ventral margin, this projection almost truncate and with the end sclerotized and slightly serrate. Lobes of tenth tergite relatively massive, the base large and bulbous, the apex more heavily sclerotized and bluntly rounded; the dorsal aspect shows a bowed condition of the projecting portion and a slightly serrate condition along the sides. Aedeagus, fig. 14*C*, with central lobe bulbous at base and slightly enlarged at tip; lateral arms with a slender, sclerotized basal half and a membranous apical portion which terminates in a wide flap edged with a comb of flattened setae.

Holotype, male.—5½ miles E. of Beaver, Utah, Aug. 28, 1946, G. F. Edmunds.

Limnephilus circopa n. sp.

This species belongs to the *mutatus* group, as shown by the broad front wings which are brown speckled with white. Within this group *circopa* resembles *nigriculus* Bks. based on the T-shaped lateral arms of the aedeagus and declivous tenth tergite, but differs in the short, trianguloid cercus without apico-ventral process; in this latter *circopa* approaches *mutatus* but differs in many points of the clasper, aedeagus, and tenth tergite.

Male.—Length from tip of head to apex of folded wings, 15 mm. Color of head, body, and base of legs, dark brown; antenna, palps, tibiae, and tarsi yellowish, the tibiae banded with darker brown. Front wings dark brown, finely speckled over the entire surface with small light spots. Head with a wart bearing 2 or 3 macrochaetae behind lateral ocellus; mesonotum with lateral wart oval, bearing about seven macrochaetae. Front legs with basitarsus nearly twice length of second tarsal segment, and with base of femur having a linear pad of black spicules along the base of the face opposing the tibia. Front wings relatively broad. Eighth abdominal segment simple, like the seventh, with no apical brush or projections.

Genitalia as in fig. 17. Ninth segment robust, produced dorsad into a low, narrow bridge, and forming a nearly square shoulder beneath the cercus. Clasper fusing imperceptibly with ninth segment, the projecting portion only moderately long, its apex cut away dorsad to form a narrow tip. Cercus of moderate length, somewhat trianguloid in shape, concave mesally and without conspicuous sclerotized areas or projections. Lobes of tenth tergite of very

curious shape, the base humplike, and the anterior portion declivous and sinuate, curving ventrad and then posterad to form a sharp, finger-like apex. Arms of aedeagus, fig. 17*B*, slender, with a ventral and dorsal projection together giving a T-shape to the structure.

Holotype, male.—Hoop Lake, Daggett Co., Utah, Sept. 2, 1947, Harold Stark.

Limnephilus alconura n. sp.

A close relative of *harrimani* Bks., *alconura* can be distinguished readily from this and related species by the lateral projections at the tip of the plates of the tenth tergite.

Male.—Length from tip of head to apex of folded wings, 14 mm. Head and body dark brown; antennae and palps yellow-brown; legs light brown, shading to yellowish at apex; front wings with strawlike ground color, with a dark band extending below M, irregular dark splotching at stigma, and darker brown clouding apex. Head with a large macrochaeta postero-mesad of each lateral ocellus. Mesonotal warts linear-oval with four stout macrochaetae. Front basitarsus one and one-half times length of second tarsal segment. Eighth abdominal tergite with apex slightly produced into a wide, blunt area bearing a few scattered rows of minute spines.

Male genitalia as in fig. 18. Ninth segment only fairly long, dorsally forming a high, narrow bridge, and narrowed ventrad to a small angle; it is fairly long across the middle and merges imperceptibly with the clasper. Clasper with only apical portion distinct and this forming a small, rounded protuberance bearing a few long hairs at apex. Cercus very long, exceeding tenth tergite; it is thin and concave mesally, with a short ventral area of the apical margin slightly serrate and definitely sclerotized. Lobes of tenth tergite long, very deep at base, with a slight postero-ventral protuberance, and with the apex narrowed and slightly upturned; in dorsal view, fig. 18*B*, the lobes diverge slightly beyond middle and each ends in a narrow truncate tip with a sharp though small lateral projection. Aedeagus typical for *harrimani* group, the lateral arms simple with the typical dorsal brush of hair on the enlarged apical portion.

Holotype, male.—Pole Cr., Crater Lake, Ore., Aug. 7, 1948, K. Fender.

LIMNEPHILUS NIGRICEPS (Zetterstedt)

Phryganea nigriceps Zetterstedt, 1840. Ins. Lapp., 1066. *Chaetotaulius striola* Kolenati, 1848. Gen. et sp. Trich. 1: 47. *Limnephilus forcipatus* Banks, 1924. Harv. Univ. Mus. Comp. Zool. Bull. 65: 439.

American specimens of the species have been treated both as a distinct species and as a subspecies of the European form. Recently we had the opportunity to compare males from Germany and northern Manitoba, and believe they are both the same species, with only very slight differences between them. These check very well with drawings made from Banks' type, fig. 13, and with McLachlan's illustrations of the species.

LIMNEPHILUS NEBULOSUS Kirby

Betten and Mosely (1940) give an extensive bibliography of this subarctic species, and describe in detail the characters of the genitalia of the

type, which is a female. Collections from Churchill, Man., by H. Elliott McClure have given us the opportunity to associate the male of this species. It agrees well with Kirby's description, and the male genitalia are illustrated in fig. 8, drawn from a Churchill specimen.

LIMNEPHILUS PRODUCTUS Banks

Limnephilus productus Banks, 1914. Can. Ent. 46: 150. *Limnephilus utahensis* Denning, 1948. Psyche 55: 18. New Synonymy.

To date this species is known only from Utah. There appears to be extremely little variation in the species, judging from examination of Banks' type, additional material from Utah, and Denning's illustrations.

Limnephilus acula n. sp.

This species is a close relative of *productus* Bks., differing in characters of the claspers and cerci as given in the foregoing key.

Male.—Length from tip of head to apex of folded wings, 15 mm. Color of body and appendages a fairly uniform reddish brown with the leg spines black and lines of darker marks on the front wings. Head with a single large macrochaeta postero-mesad of each lateral ocellus. Mesonotal warts poorly defined, linear, each bearing about seven macrochaetae. Front leg with basitarsus equal in length to following segment; femur enlarged, its inner margin with a linear brush of black spicules. Front wing widening only little at middle. Eighth abdominal tergite with its apex produced into a wide projection covered with a brush of minute setae.

Male genitalia as in fig. 25. Ninth segment large, dorsally narrowed to a thin bridge, ventrally and laterally forming a rounded outline. Clasper long and fairly robust, curving posterad and very slightly emarginate at tip. Cercus small, lateral aspect triangular, the upper apex pointed, the posterior margin below this slightly emarginate, and the emargination ending in a slight hump; ventral aspect as in fig. 25*C*, the mesal side forming a flat shelf which is incised near middle to form a narrow, sharp cleft. Lobes of tenth tergite very low, fig. 15*B*, the apex gently rounded. Aedeagus practically identical with that of *productus*, with simple lateral arms bearing a dorsal armature of setae.

Holotype, male.—Pullman, Wash., June 5, 1908.

Paratype.—Nicola, B. C., July 13, 1932, G. J. Spencer, 1 ♂. In collection of University of British Columbia.

LIMNEPHILUS PICTURATUS McLachlan

Limnephilus picturatus McLachlan, 1875. Rev. Syn. Trich. Eur. Fauna 2: 78. ♀. *Limnephilus exulans* McLachlan, 1876. Ibid. Suppl. pt. 1: 1: vi. ♂. *Limnephilus kincaidi* Banks, 1900. Papers Harriman Alaska Exp., Ent.: 468. ♂, ♀. New synonymy. *Limnephilus clausus* Banks, 1924. Harv. Univ. Mus Comp. Zool. Bull. 65: 440. ♂, ♀.

This Holarctic species is northern in general distribution with southward extensions of its American range into the Rocky Mountain series as far south as Colorado. In the North its range seems to be fairly continuous from Iceland through Sweden, Finland, Russia, Siberia, and Alaska to Hudson's Bay.

The male genitalia of specimens from various localities seem to be remark-

ably constant except for the lateral arms of the aedeagus. Within material collected from a single locality there is some variation, but some general regional trends are evident. From Colorado the lateral process is usually shorter and bears stout dorsal spines at the apex, fig. 23*C* (typical *of clausus*); and from Churchill, Man., the process is longer, slender, and has smaller dorsal spines, fig. 23*D*, and is typical of *kincaidi*. Through the courtesy of the United States National Museum we have been able to examine two males of this species from Siberia. Their lateral processes of the aedeagus resemble most those from Manitoba specimens, differing only in that there are no teeth before the apical tuft and the apical membrane is slightly narrower.

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Ecological Survey of the Mosquitoes of Southern James Bay

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Research on the American arctic and subarctic biting insects has progressed rapidly in recent years due to increased interest in these northern regions. Insecticide control of the hordes of mosquitoes that occur each summer is very difficult and expensive even in small local areas. The various species breeding in extensive and diversified habitats, together with the dispersal and migration habits of the adults intensifies the control problem. A knowledge of the bionomics and distribution of each species appears to be essential in attempting artificial or natural control. As a part of more extensive surveys, an ecological and taxonomic study was made at the southern end of James Bay, Ontario. This region is in the midst of the transcontinental northern forest. Most of the mosquitoes characteristic of this forest region are widely distributed from Alaska to eastern Canada and New England. The present observations were made from 6 to 16 June and 6 to 10 July 1949 at the southern end of James Bay from the mouth of the Moose River at Moosonee and Moose Factory Island south along the railroad to Coral Rapids and Cochrane, Ontario. Most of the collections and observations were made on Moose Factory Island, about 1½ by 1 mile in size and 3 miles from James Bay. The island has a maximum elevation of about 50 ft. and is composed of sand, gravel, and blue clay covered with humus and vegetation. The island is poorly drained and much standing water exists in the spring and early summer.

Forty field stations were established in the various types of habitats. Larvae were tentatively identified in the field using a 15X hand lens and a medicine dropper. Field identifications were confirmed, microscopic characters examined in the laboratory, and individual reared associations of larvae and pupae were made with the adults. Twenty-seven species of Culicids have been collected including four species of Chaoborines.

Larval Habitats

The northern conifer forest, although lean in numbers of plant species,

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provides an abundance of mosquito breeding sites in diverse types of habitats. Many surface pools derived from snow and ice melt and from spring rains occur as temporary breeding places. The climax transcontinental northern conifer forest is composed of white spruce *Picea glauca*, black spruce *Picea mariana*, interspersed with balsam fir *Abies balsamea*, larch *Larix laricina*, and several species of hardwoods. The ground cover is composed mainly of sphagnum moss *Sphagnum* spp. and other mosses, various heaths, and shrubs. The forest is made more diversified by the occurrence of various types of developmental stages of vegetation. The main types of plant succession and vegetation types include: a hydric series leading from (a) various depressions and oxbow lakes through a bog series consisting of (b) mosses and sedges *Carex* spp. (c) heaths as Labrador tea *Ledum groenlandicum*, bog rosemary *Andromeda polifolia*, small cranberry *Vaccinium oxycoccus* and others, and low birch *Betula glandulosa*, to (d) black spruce, tamarack, and heaths, to (e) white spruce and sphagnum moss climax. Another hydric series consists of a succession from (a) depressions and oxbow lakes, through (b) sedges, alder *Alnus incana*, willow *Salix* spp., and red-osier dogwood *Cornus stolonifera*, to (c) poplar *Populus tacamahacca*, alder, and willow, to the (d) climax. A xeric series on hills and burned areas includes (a) aspen *Populus grandidentata*, to (b) white birch *Betula papyrifera*, balsam fir, and poplar, to the (c) climax. The mosquito larval habitats include both natural and artificial habitats which were classified into the following eight main types:

1. *Climax white spruce forest.*—The climax forest is composed of white and black spruce, balsam fir, and tamarack, with a ground cover of low birch, and various heaths including Labrador tea *Ledum groenlandicum*. The ground is covered with sphagnum and fern mosses. The pools are depressions in the moss or beside rocks and trees. The water is usually acid and stained.

2. *Sphagnum-heath bog.*—This category includes the open phases of the spruce muskeg with scattered black spruce, tamarack, and heaths such as Labrador tea, bog rosemary, small cranberry and others. The acid pools are depressions in sphagnum or other mosses.

3. *Alder-willow-dogwood.*—These shrubs occur in depressions in open or disturbed spruce forest, and particularly in cottonwood groves. The pools are usually shallow, containing sedges or without vegetation. The water is neutral and clear to slightly stained.

4. *Carex marshes or swales.*—Includes open pools containing sedges and grasses in meadows and along river shores. The pools are nearly neutral and mostly clear and unshaded.

5. *Old winter roads and ditches.*—These habitats are flooded ditches and old overgrown winter roads which occur in narrow openings through spruce forest. In the larger openings sedge swales developed. These habitats produce the largest number and the most species of mosquitoes.

6. *Oxbow lakes.*—Several small streams had become blocked at the ends and then choked with vegetation such as cattail *Typha latifolia*, sedges, cinquefoil *Potentilla palustre*, and arrowhead *Sagittaria* spp. The water is clear, about neutral and fairly deep.

7. *New excavations.*—Includes drainage ditches, waste disposal pits, new roadside borrow pits and new wheel tracks. No vegetation is present, and the habitats frequently contain tin cans and refuse.

8. *Salt marsh.*—The extensive salt flats at the southern end of James Bay are covered with sedges and grasses. The pools are brackish and unshaded.

Extensive measurements of the physical factors of the habitats were not made since previous studies had failed to produce significant correlations of species occurrence with pH, temperature, or organic staining. Accutint indicator papers were used to test pH, but since these were not reliable in cold water, detailed results are not presented. The species of mosquitoes were closely correlated with vegetation type and the type of habitat. Air and water temperatures were taken with a floating type dairy thermometer.

Species succession of larvae was not noticeable during June at Moose Factory. Most of the species were in the 4th instar larval stage throughout the period when collections were made. *Aedes excrucians* were slow maturing and *Culiseta morsitans* and *Eucorethra* were in the 3rd instar during this period. *Culiseta impatiens* and *Culex apicalis* were not collected until uJly. The flowers appearing in bloom during the height of larval development were marsh marigold *Caltha palustris*, bluebells *Mertensia paniculata*, *Smilacina trifolia*, wood anemone *Anemone quinquefolia*, coltsfoot *Petasites sagittatus*, and *P. palmatus*.

Several insect predators were observed eating mosquito larvae and pupae. A number of dystiscid and gyrinid beetle larvae and a large trichoptera larva were observed eating larvae of several species of mosquitoes at Moose Factory. *Eucorethra* and *Chaoborus* were locally common and were probably of some value in reducing the larval mosquitoes.

A stalked protozoan was very abundant on about one-third of the mosquito larvae and they occurred on all parts of the body, particularly on the gills and mouthbrushes. The protozoans occurred on larvae of *Aedes canadensis*, *A. cinereus*, *A. communis*, *A. diantaeus*, *A. excrucians*, *A. fitchii*, *A. impiger*, *A. pionips*, and *A. punctor* in sedge marshes, sphagnum pools, roadside borrow pits and excavations in bog and spruce muskeg, pools in alder thickets, and snow melt pools. They were particularly abundant on larvae in dark stained water in woodland pools and in unstained water in shaded sedge swamps. All larvae infested with these protozoans completed development and transformed into pupae normally, although occasionally later than uninfested larvae. The only observed effect of the protozoans was slight impediment in larval movement, and competition for plankton food at the mouthparts since many larvae had the mouthbrushes so heavily covered that it appeared that they could not feed.

Two species of algae were observed on the anal gills and posterior body regions of mosquito larvae. The algae frequently covered the anal gills with a large green mass, and about one-third of the larvae especially *A. excrucians* and *A. fitchii* were infected. The algae were most abundant on larvae in unshaded pools of clear or slightly stained water. They apparently had no harmful effects since the infected larvae developed and pupated normally, leaving the algal growth on the discarded last larval skin.

ECOLOGY OF THE MOSQUITOES

Aedes campestris.—Adult specimens were collected on Charlton Island in southern James Bay on 19 July 1918 by H. N. Awrey. The larva of this species is known to occur in salt marshes, but none were found during the 1949 survey. At Moose Factory and at Moosonee several adult females which were either this species or *A. dorsalis* were collected while biting human beings on 6 and 7 July.

Aedes canadensis.—Larvae of this species were collected at Moose Factory and at Moosonee in a variety of artificial and natural pools. The habitats included pools under alder, willow, and dogwood, temporary vernal pools in open meadow, sedge marshes, wheel tracks, open artificial ditches, and refuse pools. The pools were of various sizes and from 3 in. to 2 ft. deep. The bottoms of the pools were covered with organic debris and leaves, except in

TABLE 1.—Larval Habitats of Mosquitoes of Southern James Bay

	Climax Spruce Forest	Sphagnum-heath Bog	Alder-willow-dogwood	Carex Marsh and swale	Old Winter Roads and Ditches	Oxbow Lakes	New Excavations	Salt Marsh	Pitcher Plant
A. campestris								×	
A. canadensis			×	×	×		×		
A. cinereus			×	×	×				
A. communis	×	×			×				
A. diantaeus	×	×	×		×				
A. dorsalis								×	
A. excrucians			×	×	×				
A. nr. excrucians				×	×				
A. fitchii				×	×				
A. flavescens								×	
A. implacabilis									
A. impiger			×		×				
A. intrudens				×	×				
A. pionips	×		×		×				
A. punctor	×	×	×			×			
A. sticticus									
A. stimulans							×		
A. vexans									
C. impatiens					×				
C. morsitans			×	×	×	×			
Culex apicalis					×				
Wyeomyia smithii									×
Mansonia perturbans									
Mochlonyx fulignosa					×				
Mochlonyx culiciformis				×	×				
Eucorethra underwoodi	×	×							
Chaoborus flavicans									

TABLE 2.—Larval Associations of Southern James Bay Mosquitoes*

	A. canadensis	A. cinereus	A. communis	A. diantaeus	A. excrucians	A. nr. excrucians	A. fitchii	A. impiger	A. intrudens	A. pionips	A. punctor	A. stimulans	C. impatiens	C. morsitans	Culex apicalis	Wyeomyia smithii	M. fulignosa	M. culiciformis	E. underwoodi
A. canadensis	5	2	3	2		1	1	1		3	2		1				1		
A. cinereus		3	4	4	2	2	2	1	2	3			2				3		
A. communis			5	2	1	2	2	2	3	8							2		
A. diantaeus				2	1	1	2	2	3	6			1				3		
A. excrucians					2	2	2	2	3	6			3				2		
A. nr. excrucians						2	1	1	1	1							1		
A. fitchii							1	2	1	2							1		
A. impiger								1	1	2							1		
A. intrudens									1	2							1		
A. pionips										4			1				3		
A. punctor													2				3		
A. stimulans																			
C. impatiens															1		1		
C. morsitans																		1	
Culex apicalis																	2		
Wyeomyia smithii																			
M. fulignosa																			
M. culiciformis																			
E. underwoodi																			

* The numbers represent the number of times two species occurred together in the same habitat.

sedge and grass pools which had no debris. The water was clear to turbid or slightly stained with organic material, about neutral and with variable temperature. Larvae were fairly common and well distributed in about one-third of the field stations, and were collected from 6 to 16 June as 3rd and mostly 4th instar larvae. Pupation was general by 14 June. Larvae were frequently observed near the surface of the water, but they did not respond to sudden changes in environment as rapidly as many other species.

Adults were collected biting human beings during the middle of the day in a spruce forest on 8 July near Cochrane.

Aedes cinereus.—This species was one of the most common mosquitoes of the southern James Bay area, being taken in over half of the field stations. It was collected at Moosonee, Moose Factory, and Coral Rapids. The most characteristic habitats were pools under alder, willow, and dogwood in spruce muskeg forests. Other habitats included water standing in overgrown winter roads, old roadside ditches, sedge marshes and swales in climax spruce muskeg. The pools were of variable size usually less than one ft. deep and the bottoms of the pools were often covered with organic debris and decaying leaves.

A characteristic larval habitat was mats of filamentous algae. The water was slightly stained, containing suspended organic material or iron flocculate, to nearly clear. The water temperatures were variable and the pH neutral. Larvae were collected from 6 to 16 June. They were fairly common but never abundant, usually 1-2 per dip. The larvae were sometimes infested with protozoans and algae.

No adults of this species were collected.

Aedes communis.—Larvae of this species were found in roadside and railroad ditches through muskeg forest at Moose Factory and Coral Rapids. They were also found in old drainage ditches overgrown with alder and willow, in flooded winter roads, and in sphagnum pools in spruce-fir muskeg. The water was usually stained and contained some organic colloids. The pools were frequently shaded and often contained decaying spruce logs or branches and the bottoms of the pools were covered with decaying organic material. Larvae were collected as 4th instar from 6 to 16 June in only 7 stations, and usually less than 1 larva per dip. They usually occurred at the surface and were readily disturbed by change of light. Frequently the larvae were covered with a ciliate protozoan, particularly on the mouthbrushes, but they were rarely infested with algae.

Adults were collected biting human beings at 6:00 to 9:00 P.M. in spruce muskeg and along winter roads, and at noon near bogs from 10-16 June and 6-8 July at Moose Factory and Cochrane. A male swarm was observed at Moose Factory at 9:00 P.M. on 15 June in open meadow about 800 feet from any trees. Five males flew back and forth from 4 to 8 feet above the ground. A very slight wind was blowing which kept the swarm oriented. The temperature was 67°F. and the light intensity was 100 Weston units. Another swarm was observed at the edge of a cottonwood forest and the few males danced back and forth from 5 to 10 feet above the ground.

Aedes dianteus.—Larvae were collected at Moose Factory, Moosonee, Coral Rapids, and Cochrane in old roadside ditches and borrow pits in spruce muskeg, in temporary pools under alder, willow, and dogwood, and in shallow pools in cottonwood and alder groves. A few larvae were collected in sedge and grass swales and sphagnum pools in spruce muskeg. The shaded or unshaded pools were 3 in. to 3 ft. in depth, and the bottoms were covered with decayed organic material including dead leaves and fine colloidal organic debris. The water was clear or deeply stained and with much suspended colloidal organic material, but not turbid with suspended silt. The pH was acid to nearly neutral and the water temperatures were variable.

The larvae were often below the surface of the water and were easily disturbed. They moved rapidly and were not easy to collect, even though the distinctive yellow color of the larvae made them conspicuous in the darkly stained water. They appeared to feed on free plankton since they kept the mouthbrushes moving in open water or while suspended from the surface by the airtube. Third and 4th instar larvae were collected from 6-16 June and adults were reared in the laboratory on 10 June. The larvae were common at

Figs. 1, 2.—1. Borrow pit filled with refuse in which larvae of *A. stimulans* and *A. canadensis* occur (upper); 2. Sedge filled ditch along winter road containing larvae of *A. excrucians*, *A. fitchii*, and *A. cinereus* (lower).

6 stations, and thirty-five were identified in the laboratory and about 100 additional in the field.

Adult females were collected biting human beings at noon on 8 July in spruce woods near Cochrane.

Aedes dorsalis.—Adults were collected at Moose Factory, 26 July 1918 by H. N. Awrey. During the 1949 survey, no larvae were collected, but adults which were probably this species were collected biting human beings in sunlight at noon at Moosonee, and on Moose Factory Island at 10:00 P.M. on 6 and 7 July. This species breeds in the extensive salt marshes at the south end of James Bay, and these specimens had probably migrated one to 3 miles inland.

Aedes excrucians.—Larvae were found at Moose Factory and Moosonee in open unshaded pools which usually contained vegetation, particularly Carex sedges. They were most abundant in a flooded area beside a winter road at the border of a cottonwood grove, and were also found in pools under alder, willow, and dogwood where sedges and grass were present. The pools were of variable size, from 6 to 18 in. deep, and the bottoms were covered with dead grass, sedges, and often some organic material. The water was either clear or slightly stained. The large larvae were usually hidden on and under dead sedges and grass leaves where they moved slowly, eating accumulations of plankton and other deposited organic material. It was usually necessary to dip under the plants to collect the larvae. The populations were quite large and in these particular habitats, were the most abundant species. Usually only 1 to 3 larvae per dip were collected, during the period 7 to 16 June.

Adults were collected while biting human beings at noon on 8 July in a spruce forest near Cochrane.

Aedes sp. near *excrucians.*—Larvae of this species were found with *A. excrucians* in a shaded flooded area beside a winter road at the border of a cottonwood grove. The larvae occurred on dead sedge leaves where they ate accumulations of plankton and organic debris. The pools were about one ft. in depth. The water was clear to slightly stained. Only a few larvae were collected from 8-10 June.

Aedes fitchii.—Larvae were collected at Moose Factory in pools containing sedge, grass, and horsetail *Equisetum* spp. along winter roads through spruce muskeg, and in pools under willow, alder, and cottonwood. The pools were usually several feet in diameter, 1-2 ft. deep, and contained dead submerged sedge leaves. The water was slightly stained and slightly acid to neutral. The larvae were rarely found at the surface and then only in open water. They were usually observed and collected grazing on accumulated debris and plankton on and under dead leaves of sedge and grass. Only 16 larvae were collected by dipping under the dead leaves from 8-14 June. The anal gills of the larvae were usually heavily infested with algae and the mouthparts frequently had protozoan infestations.

Aedes flavescens.—Large specimens were collected at Albany, Ontario at the mouth of the Albany River, on James Bay, 10 July 1918 by H. N.

Awrey. This species was not collected during the present survey but probably occurs in the nearby salt flats.

Aedes impiger.—Larvae were collected at Moose Factory in overgrown shaded artificial drainage ditches and roadside borrow ditches and in a pool under alder and willow shrubs in a cottonwood grove. The habitats were relatively shallow ditches or shallow pools, with the bottoms covered with dead leaves, and the water stained with organic colloidal material. The larvae were similar to *A. communis* in habits and appearance. They fed near the surface and were readily disturbed and wriggled to the bottom. Larvae were collected from 7 to 15 June but were not common and were found only in restricted habitats. The mouthparts were heavily infested with protozoans and a few larvae had algae on the gills.

Aedes implacabilis.—This species occurs very early and no larvae were found. An adult male was collected in undergrowth in spruce forest at Moose Factory on 12 June. Females were collected while biting human beings from 6 to 10 P.M. on 14 June and 6 July at Moose Factory, and at noon at Coral Rapids on 7 July.

Aedes intrudens.—Larvae were collected at Moose Factory in spruce muskeg in a flooded winter road and a roadside sedge and grass swale. The pools were 6-12 in. deep and were recently flooded from early summer rains. The vegetation near the partly shaded pools was willow and alder with some sedges growing in the water. The water was slightly stained and the bottoms of the pools were covered with decayed organic material. Three larvae were collected at two stations from 8-11 June and two males and a female were reared in the laboratory.

Adult females were collected biting human beings at Moose Factory at 10:00 P.M. on 6 July and at 6:00 A.M. on 7 July, in spruce forest and along a river bank.

Aedes pionips.—This is a pioneer species found in disturbed sites in climax spruce forest. Larvae were collected in railroad ditches in spruce muskeg near Coral Rapids, and at Moose Factory they were common in roadside ditches, borrow pits, and in shallow pools among alder and willows. The pools were from 3 in. to 2 ft. in depth usually shaded, and the bottoms were often covered with debris and organic material. No vegetation types or plant species were closely associated, but some larvae were found among sedges. The water was light to dark stained with organic colloidal material. A few pools contained nearly clear water, but the populations were low. The larvae feed at or near the surface and are readily disturbed by change in light or jarring of the ground. They descend rapidly and are somewhat difficult to collect, although the large dark body of the mature larva is readily observed in clear water. Third and 4th instar larvae were commonly collected from 6 to 15 June, often 3 to 100 per dip. The larvae were sometimes infested with a stalked protozoan on all parts of the body, and with algae on the anal gills of specimens from unshaded habitats.

No adults were collected biting human beings.

Aedes punctor.—Larvae of this species were collected at Moose Factory, Moosonee, and Coral Rapids. The most typical habitats were small pools in the spruce muskeg in pools under overturned spruces, and in roadside ditches in the spruce forest. They were also found in pools under alder, willow, and dogwood, in old wheel tracks in the forest, in heath bogs, and in old flooded roads. The pools were shaded or unshaded, variable in size, and usually from 4 in. to 1½ ft. in depth, with the bottoms covered with decaying organic material or moss. The water was slightly to heavily stained, and with variable temperature and pH. Larvae were found commonly in 20 stations from 6 to 15 June with populations of 1 or less to 5 per dip. They were usually near the surface, and were readily disturbed by change in light intensity. Larvae were usually heavily infested with a stalked ciliate protozoan particularly on the mouthbrushes, but the anal gills were rarely infested with algae.

Male swarms of *A. punctor* were observed at Moose Factory on 15 June. Five swarms were studied from 8:00 to 9:30 P.M. when it became dark. The air temperature averaged 67°F. Three swarms of 40 to 50 males each, moved back and forth at from 5 to 10 feet above the ground in openings in a road between white spruce trees about 50 feet in height. The swarms were definitely aggregated but the males were not closely associated. Swarming was interrupted briefly by rain at 8:20 P.M. but they reformed and were active until darkness. Another swarm was composed of 20 males flying back and forth from 8 to 20 ft. above the ground in a large clearing. When a wind arose, the swarm became more tightly bunched. A fifth swarm was composed of about 25 males flying back and forth 5 to 10 ft. above the ground at the edge of a cottonwood and alder forest. Males were collected from each swarm for identification.

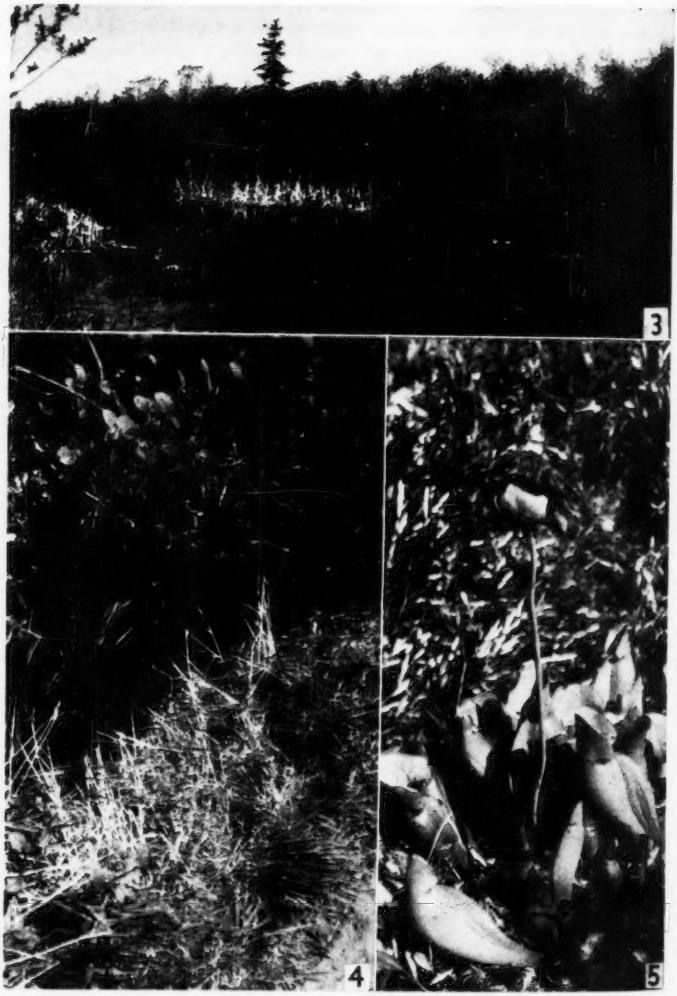
Female mosquitoes were collected biting human beings in spruce forests.

Aedes sticticus.—The larvae of this species usually breed along the overflowed banks of streams. No larvae were obtained during the present survey, but 13 adults of this species were collected while biting human beings during the evening of 15 June along a winter road through a spruce forest near the Moose River. Females were collected biting human beings at noon at Coral Rapids on 7 July.

Aedes stimulans.—Larvae were collected at Moose Factory in several artificial pools about 8 ft. in diameter and 2 ft. in depth, containing old tin cans and refuse. No live vegetation was in the pools which were fully exposed to the sun in open fields and along the coast. The water was turbid with suspended silt and organic debris. Larvae were collected in small numbers from 7 to 12 June in this type habitat.

Aedans vexans.—Adult females were collected while biting human beings at noon on 8 July at the edge of an aspen grove near Cochrane. One male was collected at noon in this locality.

Culiseta morsitans.—Larvae of this species were common only in specific habitats at Moose Factory. They occurred among the dead sedge plants under alder and willow and occasionally dogwood. The most important



Figs. 3-5.—3. Blocked stream channel containing *Culiseta morsitans;* 4. Ditch along winter road in which *A. diantaeus* and *A. punctor* occur; 5. Pitcher plant *Sarracenia purpurea* with hollow leaves containing water and larvae of *Wyeomyia smithii.*

habitat was a choked stream channel about 15 ft. wide and 2-3 ft. deep containing sedges, cattail, *Potentilla palustre* and several floating aquatics. Larvae were also found in a sedge filled borrow pit beside a winter road through spruce muskeg. The bottoms of the pools were covered with decaying organic debris including sedge plants and leaves from various trees and shrubs. The water was slightly stained and contained some suspended organic colloidal material. Second to 4th, mostly 3rd instar larvae were collected from 7 to 16 June, but none were reared to adults in the laboratory. The larvae remained at the surface of the water and moved forward by the action of the mouthbrushes and setae. Larvae were most abundant in shaded recesses along the banks and between roots and branches.

No adults were collected.

Culiseta impatiens.—Larvae and pupae were collected at Moose Factory on 7 July in a ditch 1 ft. wide and deep beside an old winter road. The water was stagnant and filled with moss and some other vegetation. No adults were collected earlier in the season.

Culex apicalis.—Larvae were collected at Moose Factory in a ditch along a winter road in a spruce forest on 7 July. The water was darkly stained and contained moss. No adults were observed.

Wyeomyia smithsii.—Larvae and pupae were collected in the water in the leaves of the pitcher plant *Sarracenia purpurea* on 8 July in a sphagnum bog west of Cochrane. The water in the pitchers was relatively warm and turbid and contained the remains of many insects. Chironomid larvae were also present. A few adults were observed in or near the leaves of the plants.

Mansonia perturbans.—Adult females of this species were very abundant and bit human beings readily at noon on 9 July in a spruce forest near a bog lake west of Cochrane.

Eucorethra underwoodi.—Larvae of this species were commonly collected at Moose Factory in pools under roots or tree trunks and in deeper pools in sphagnum or fern moss in spruce forest. The water in the pools was usually permanent, relatively cool and darkly stained. The larvae were frequently found near or somewhat below the surface of the water in recesses, or partly hidden along the sides. They remained motionless for long periods of time but moved rapidly when a mosquito larva came nearby. They were predacious on *A. punctor* and several other species of mosquitoes that lived in these habitats. Frequently pools containing *Eucorethra* had no mosquito larva while similar pools nearby contained many larvae. The developmental period was apparently quite long by comparison with *Aedes* larvae and most of the larvae were 3rd instar from 6 to 16 June.

Mochlonyx culiciformis.—These predacious larvae were found at Moose Factory and Coral Rapids in pools shaded by alders and willows in cottonwood groves, in old borrow pit ditches along winter roads, and in ditches along a railroad in a spruce forest. The pools and borrow ditches were 3 in. to 1½ ft. in depth, and the bottoms of the pools were covered with decaying leaves and organic debris. The water was slightly stained and somewhat acid.

The larvae were found from 1 to several inches below the surface of the water where they remained suspended horizontally. They were predacious on mosquito larvae and other aquatic organisms. Larvae were collected commonly from 6 to 16 June.

Mochlonyx fulignosa.—Larvae and pupae were collected in numbers at Moose Factory on 7 July in a small borrow pit in spruce muskeg and also in a roadside ditch containing algae. The water was heavily stained and contained much colloidal organic material.

Chaborus flavicans.—A single male was collected at noon on 8 July near a sphagnum bog in a spruce forest west of Cochrane.

SUMMARY

An ecological survey of mosquitoes was made at the southern end of James Bay from Moose Factory at the mouth of Moose River to Cochrane, Ontario from 6 to 16 June and 6 to 10 July 1949. The mosquitoes are typical of the subarctic northern transcontinental conifer forest in which this area occurs. Twenty-seven species of culicids have been collected including four species of chaoborines. The larval habitats, vegetation types and observations on the larval habits are presented for each species. The most abundant species were *Aedes punctor* and *A. excrucians*. A stalked protozoan and algae were found on the larvae. The dates of occurrence of larvae and adults, and biting records of adults are given. Male swarms of *A. communis* and *A. punctor* were observed. Most of the species were reared in the laboratory and individual associations were made of larvae, pupae, and adults for taxonomic studies. Control of the mosquitoes would be difficult due to the extensive area and variable types of habitats in which the larvae occur.

Ecological Notes on Mosquitoes of Lafayette County, Wisconsin (Diptera: Culicidae)

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Mosquitoes were collected, reared and breeding habits studied for three summers (1948, 1949, 1950) in southwestern Wisconsin. The following presentation is a compilation of ecological data with several collection records for Lafayette County, Wisconsin.

The author's identification for *Aedes excruscians*, *Aedes sticticus* and *Culex restuans* was confirmed by Dr. Alan Stone of the U. S. Bureau of Entomology, Washington, D. C.

Distributional data and keys were used from the following sources—Dickinson (1944), Matheson (1944) and Ross (1947).

Ecological and Distributional Data

Anopheles punctipennis (Say).—Larval Collections*: 3rd instar from seepage of sunlit grassy meadow, VIII-13-1950. 3rd. instar from shady artificial container, IX-7-1949. 3rd. instar from large stock tank containing algae, exposed to sun, IX-7-1949. Adult Collections*: From poultry buildings, VIII-3, 16, 17, 23, 24, 25-1949 and IX-7-1949.

Aedes excruscians (Walker)†.—Adult Collections*: Taken while not biting, VIII-23-1948.

Aedes trivittatus (Coquillett)†.—Adult Collection*: Taken while biting, VI-25-1950.

Aedes sticticus (Meigen)‡.—Adult Collection*: Taken while biting, VI-21-1950.

Aedes triseriatus (Say)†.—Larval Collections*: Tree hole (Live Elm) 15′ above ground. 3rd instar larvae, VII-5-1950. 4th instar larvae, VIII-17-1950. Tree hole (Dead Linden) 2′ above ground. 4th instar, VIII-13-1950. Larval Collections**: Rain water in old tires, VI-2-50 (adults reared). Adult Collections*: Taken while biting, VI-25-1950. Taken while not biting, VIII-3-1949 and IX-7-1949.

Aedes vexans (Meigen)†.—Adult Collections*: Taken while biting, VI-25-1950. Taken while not biting, VIII-3, 7, 10, 25-1949.

Culex apicalis Adams†.—Larval Collections*: Seepage in sunlit grassy meadow, VIII-13-1950 (adults reared).

Culex tarsalis Coquillett.—Larval Collection*: Seepage in sunlit grassy meadow, VIII-13-1950 (adults reared).

Culex restuans Theobald.—Larval Collections*: Seepage in sunlit grassy meadow, VII-13-1950 (adults reared). 4th instar from improperly covered drain barrel with mud bottom (adults reared). 4th instar from very rusty, sunlit water in metal container, VI-23-1950 (adults reared). 4th instar from metal container in shade, IX-7-1949. 3rd instar from muddy unused hog fountain, VI-30-1950 (adults reared). Adults reared

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* Collected at Shullsburg, Wis. ** Collected at Darlington, Wis. † This species has not previously been reported from Lafayette Co. ‡ First report of species from Wisconsin.

from rain water in tires, VI-21-1950. LARVAL COLLECTION**: 4th instar from rain water in tires, VII-2-1950 (adults reared).

Culex salinarius Coquillett†.—LARVAL COLLECTION*: 4th instar from seepage in sunlit grassy meadow, VIII-13-1950 (adults reared).

Culiseta inornata (Williston)†.—LARVAL COLLECTION*: 4th instar from improperly covered drain barrel with mud bottom, VI-23-1950.

Uranotaenia sapphirina (Osten Sacken)†.—ADULT COLLECTION*: Taken at light trap, VIII-7, 23-1949.

Aedes trivittatus and *A. triseriatus* were the most vicious biters encountered. Specimens were easily collected in a wooded area in late afternoon by exposing bared arms or back and using an aspirator. Three larvae of *Culicoides* sp. were found feeding in a dead larva of *A. triseriatus*. Experimentation proved the *Culicoides* larvae to be saprophytic and not parasitic.

Aedes sticticus has been reported from several localities in northern Illinois, but this is the first report from Wisconsin known to the author.

Culex restuans is by far the most prevalent mosquito breeding in artificial containers about buildings and barns. On several occasions larvae were collected, a portion of them being killed and the remainder reared. The larvae were all *C. restuans* while many of the adults lacked the mesonotal spots characteristic of *C. restuans* and resembled *C. pipiens*. It is apparent that many *C. restuans* females lack the two mesonotal spots and could easily be mistaken for *C. pipiens*.

Uranataenia sappirina was taken at a light trap at least ½ mile from the nearest marsh. Many water-filled artificial containers were near the light trap, but larvae were not found after a diligent search. Only three specimens were taken which would indicate that breeding was quite limited.

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* Collected at Shullsburg, Wis. ** Collected at Darlington, Wis. † This species has not previously been reported from Lafayette Co. ‡ First report of species from Wisconsin.

Monogenetic Trematodes of Westhampton Lake Fishes. I. Two New Forms*

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This paper is the first of a series from a recent study on monogenetic trematodes of Westhampton Lake** fishes. It comprises descriptions of two new species.

Techniques of previous workers (Mizelle, 1938; Mizelle and Cronin, 1943) were extensively employed in preparing the worms for study and several new methods were devised and utilized. A new technique of recovery involved immersion of branchial material in a small Petri dish of tap water in which a few crystals of Chloretone (Parke-Davis) had been dissolved. The gills were left therein until the worms were relaxed, then the parasites were micropipetted onto slides which had been prepared for affixing. It is possible that this method damages the delicate tissues of the flukes less than does the freezing technique, but further experimentation must be done before any definite conclusions can be made.

Haupt's adhesive (see Johansen, 1940) proved to be the most effective affixing agent. Practically all of the parasites remained on the slide when they had been properly affixed. One can shorten the affixing process by dispensing with the separate application of formalin in the hardening process by preserving the worms in 3-4 per cent formalin and pipetting them directly from the fixative onto the coated slide. After adhesion the non-formalized worms were fixed in Carnoy's solution or 70 per cent alcohol.

Some of the worms were mounted unstained on slides using the glycerine-jelly technique as described by Mizelle and Cronin (1943).

Other unstained parasites were upgraded from 70 per cent through 100 per cent alcohol into Euparal. This is a new technique for freshwater Monogenea and is superior to the glycerine-jelly method in that it produces a permanent mount and does not obscure the "chitinous" parts which are of critical taxonomic importance.

Some specimens were stained, and while results were not uniform and often unsatisfactory the process often revealed structures that were not otherwise apparent. Differential staining is very helpful and it seems probable that new and better staining techniques could be perfected.

Observations were made also on living material. Measurements and drawings were made with the aid of a calibrated ocular micrometer and camera lucida. All measurements were made across the arc described by curved structures. Cotypes of related forms were studied for comparison.

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* Contribution from the Department of Biology, University of Richmond, Virginia. (Author's present address: Florida State University, Tallahassee.)

** A 12 acre pond on the University campus.

In the descriptions below the number of worms or structures measured is given in parentheses followed by the average measurements and the minima and maxima involved.

ACKNOWLEDGEMENT

The author wishes to express his thanks to Dr. John D. Mizelle of the University of Notre Dame for his advice and aid, to Dr. J. F. Mueller of Syracuse University for his papers, to Dr. A. Seamster of Del Mar College for his papers, to Dr. E. W. Price of the U. S. Bureau of Animal Industry for making working materials available at the U. S. Nat'l. Mus. Helminth. Coll., to Director R. T. King of Roosevelt Wildlife Forest Experiment Station for loans of cotype materials, and to Dr. E. C. Raney of Cornell University for his assistance with the identification of host material.

Urocleidus doloresae n. sp.

Figs. 1-21

Host: *Chaenobryttus coronarius* (Bartram), Warmouth Bass.
Locality: Westhampton Lake, Univ. of Richmond, Va.
Type specimens: Paratypes will be placed in the U. S. Nat'l. Mus. Helminth. Coll.
Specimens studied: Fourteen.

Description: Relatively large tetraonchids which possess a smooth cuticula that is devoid of scales and spicules. Body length (14) 0.854 mm (0.387-1.4 mm), greatest body width (14) 0.158 mm (0.092-0.0215 mm). Cephalic width 0.115 mm and peduncle width (9) 0.095 mm (0.069-0.146 mm). The haptor is broadly united to the peduncle and ovate to discoidal in shape. Haptor width (9) 0.12 mm (0.116-0.142 mm), haptor length (4) 0.069 mm (0.059-0.085 mm). The four anchors are short with thick bases and very little root differentiation; hooks fourteen (see Fig. 1). Ventral anchor length (12) 0.03 mm (0.026-0.031 mm), ventral anchor base width (3) 0.021 mm (0.018-0.023 mm). Dorsal anchor length (13) 0.027 mm (0.023-0.034 mm), dorsal anchor base width (3) 0.017 mm (0.011-0.019 mm). Dorsal and ventral bars nonarticulate and somewhat variable in shape having slightly different medial configurations and variably expanded ends (see Figs. 6-12). Ventral bar length (4) 0.018 mm (0.012-0.021 mm), dorsal bar length (4) 0.02 mm (0.015-0.023 mm). The haptoral hooks have a continuously narrow shaft with little proximal expansion, a sickle-shaped termination and an opposable piece, and measure as follows: Hook pair No. 1 (4) 0.017 mm (0.013-0.021 mm), No. 2 (4) 0.021 mm (0.019-0.022 mm), No. 3 (4) 0.021 mm (0.019- 0.023 mm), No. 4 (6) 0.022 mm (0.021-0.023 mm), No. 5 (2) 0.009 mm (0.007-0.012 mm), No. 6 (6) 0.021 mm (0.018-0.023 mm), and No. 7 (3) 0.023 mm (0.019-0.028 mm). The posterior eye spots are slightly larger than the anterior ones and are transversely elongated. Anterior eye spots (8) 0.029 mm (0.024-0.039 mm) and posterior eye spots (11) 0.034 mm (0.015-0.044 mm) from center to center. Pharynx oval in shape; transverse diameter (14) 0.035 mm (0.023-0.05 mm). The shape of the cirrus and accessory piece is characteristic of this species. Cirrus a short hollow tube with slight undulations and a cirral thread wound loosely around it. In some instances this thread is widened and connected to the

shaft forming a slight cirral vane around the distal third of the cirrus (see Figs. 14, 16, 17 and 19). Cirrus length (11) 0.038 mm (0.032-0.045 mm). Accessory piece shorter than the cirrus, wide, flat and slightly forked distally to partially enclose the cirrus (see Figs. 13, 15, 18, 20). Accessory piece length (8) 0.026 mm (0.015-0.042 mm). Vagina not observed.

*Urocleidus doloresae** n. sp. appears to be similar to *U. attenuatus* Mizelle, 1941, but differs from its apparent nearest relative in possessing a cirral thread and vane, a shorter and differently shaped cirrus and no conspicuous vagina.

Genus OCTOMACRUM Mueller, 1934

This genus has not been encountered since Mueller (1934) erected it for *Octomacrum lanceatum* Meuller, 1934, the type species. This report is especially interesting because the species described is the second in the genus thus strengthening it.

Octomacrum microconfibula** n. sp.

Figs. 22-29, 36-42

Host. *Notemigonus crysoleucas crysoleucas* (Mitchill), Eastern Golden Shiner.

Locality: Westhampton Lake and the creek below the dam, University of Richmond, Va.

Type specimens: Paratypes will be placed in the U. S. Nat'l. Mus. Helminth. Coll.

Specimens studied: Ten.

A comparative study was made between this worm and Mueller's cotype slides of *Octomacrum lanceatum* Mueller, 1934 to eliminate the possibility of synonymy. A total of eleven *O. lanceatum* were examined and drawings and measurements were made. Fig. 30 shows one of its clamps.

Description: The structures that are not mentioned here are those which are the same as described by Mueller (1934) as characteristic for the genus.

Cuticula fairly thick and smooth. Body length (9) 4.35 mm (2.5-6.0 mm), greatest body width (9) 0.906 mm (0.522-1.4 mm). Body shape lanceolate; the peduncle is slightly constricted and the anterior end tapers to a rounded tip. Body width at oral suckers (6) 0.158 mm (0.122-0.184 mm), body width at genital sucker (7) 0.308 mm (0.215-0.385 mm). Peduncle width (9) 0.278 mm (0.152-0.46 mm), haptor (6) 0.604 mm wide x 0.371 mm long (0.3 mm wide x 0.308 mm long—0.924 mm wide x 0.385 mm long). The width of the haptor decreases slightly as it progresses posteriorly giving it a slight trapezoidal shape. The haptor is armed with eight clamps and two extremely small hooks (discussed in detail below). Distance from pharynx to genital sucker (5) 0.26 mm (0.215-0.307 mm). The mouth is terminal, and the oral chamber is funnel shaped with the apex of the funnel posteriorly located. Two oral suckers are situated in the posteriolateral walls

* Named in honor of my wife Dolores M. Hargis whose able assistance aided this work greatly.

** Meaning "little clamp."

of the oral chamber; they are used to grasp food and secure temporary anchorage, and measure as follows: Right oral sucker (6) 0.049 mm wide x 0.058 mm long (0.037 mm wide x 0.038 mm long-0.055 mm wide x 0.077 mm long), left oral sucker (5) 0.052 mm wide x 0.063 mm long (0.441 mm wide x 0.048 mm long-0.064 mm wide x 0.077 mm long). A thick, muscular oval pharynx with an opening of small diameter projects into the oral chamber from the posterior wall. It is very flexible and capable of much activity. Pharynx (5) 0.07 mm wide x 0.086 mm long (0.052 mm wide x 0.074 mm long-0.092 mm wide x 0.096 mm long). A very short esophagus that branches quickly into two main crura follows the pharynx; many small diverticula open into the crura from all quarters. Neither the diverticula nor the crura anastomose. The genital pore, the common opening for organs of both sexes, is surrounded by the genital sucker. In *O. microconfibula* the genital sucker commonly assumes an unusual rectangular shape and is comparatively large, measuring (8) 0.135 mm wide x 0.139 mm long (0.096 mm wide x 0.099 mm long-0.156 mm wide x 0.166 mm long). The ovaries and testis are as described by Mueller (1934) for *O. lanceotum* as are the other features of the copulatory complex except the uterus of *O. microconfibula* is smaller. There is no vagina in this form. Genito-intestinal canal runs from the right crus of the intestine to the oviduct. The excretory and nervous systems were not apparent but are probably like those of *O. lanceatum*. The most distinctive feature of this species is the comparatively small size of the haptoral clamps whose measurements are: Right clamps; No. 1 (7) 0.108 mm wide x 0.093 mm long (0.09 mm wide x 0.077 mm long-0.119 mm wide x 0.11 mm long), No. 2 (8) 0.108 mm wide x 0.009 mm long (0.074 mm wide x 0.074 mm long-0.131 mm wide x 0.119 mm long), No. 3 (8) 0.107 mm wide x 0.087 mm long (0.088 mm wide x 0.07 mm long-0.138 mm wide x 0.11 mm long), No. 4 (7) 0.079 mm wide x 0.069 mm long (0.046 mm wide x 0.061 mm long-0.098 mm wide x 0.079 mm long); it can be seen that Nos. 1, 2 and 3 are subequal but No. 4 is much smaller. Left clamps; No. 1 (7) 0.104 mm wide x 0.833 mm long (0.088 mm wide x 0.625 mm long-0.131 mm wide x 0.11 mm long), No. 2 (7) 0.113 mm wide x 0.089 mm long (0.094 mm wide x 0.081 mm long-0.123 mm wide x 0.11 mm long), No. 3 (8) 0.103 mm wide x 0.089 mm long (0.081 mm wide x 0.074 mm long-0.131 mm wide x 0.105 mm long), No. 4 (7) 0.08 mm wide x 0.067 mm long (0.068 mm wide x 0.049 mm long-0.098 mm wide x 0.087 mm long); the size similarities mentioned above apply to the left clamps also. (Fig. 38a shows the clamp of *O. microconfibula* well.) The terminology used to identify the clamp parts is that of Sproston (1945) with the exception that the term *center piece* is herewith proposed to identify the median longitudinal supporting sclerite of the clamp (see Figs. 32 and 40 for this structure). There are two small, oddly shaped haptoral hooks situated between clamps No. 4 near the posterior border (see Figs. 28 and 29) which are much like those of *O. lanceatum*.

An egg which was in the uterus of one of the specimens is pictured in Fig. 37; it is narrowly elongate like a fishing bobber and has a short terminal fila-

ment at the posterior (in utero) end and a very long, much coiled filament at the anterior end. This anterior filament is probably of importance in securing anchorage for the egg on the gills of fishes. The wall of the egg is fairly smooth and 0.004 mm thick. It is not at all like that figured by Wright (1879) which was later identified as the egg of *O. lanceatum* by Mueller (1934). This means either that Wright's egg is not that of *O. lanceatum* or that *O. lanceatum's* egg is very different from that of *O. microconfibula* n. sp.

This parasite is definitely a member of the genus *Octomacrum* Mueller, 1934, and it is considered a new species because it diverges in several distinct respects from the only other described species of the genus, *O. lanceatum*, to which it is closely related. A résumé of the differences follows: The haptor is somewhat trapezoidal whereas that of *O. lanceatum* is rectangular. The oral suckers are smaller, but the genital sucker is larger by 0.01 mm in width and length than Mueller's worm: The genital sucker of the latter is round to oval in shape, and that of *O. microconfibula* n. sp. is regularly rectangular. Another point of difference is that the haptoral clamps of the new fluke are regularly smaller than those of *O. lanceatum* Mueller, 1934 by 0.1-0.15 mm, this size difference is thought to be significant in view of the nature of the "hard" supporting framework of the clamps. (Fig. 30 is a comparison drawing of the clamp of *O. lanceatum* Mueller, 1934.)

SUMMARY

Several new techniques for handling the small monogenetic trematodes have been discussed, and *Urocleidus doloresae* n. sp. and *Octomacrum microconfibula* n. sp. have been described.

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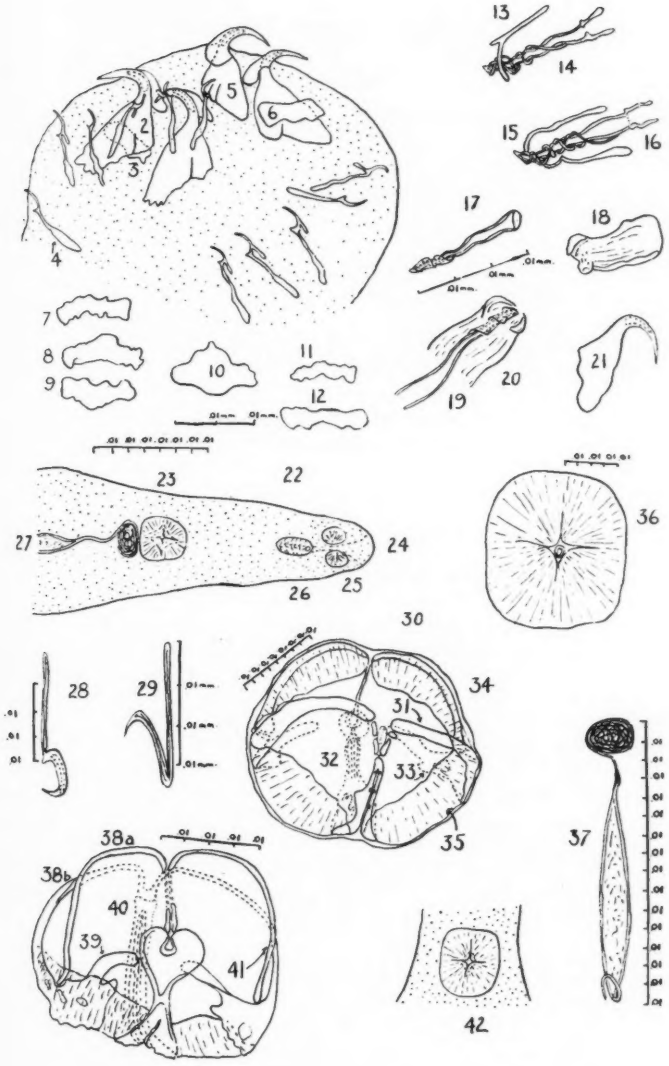
Figs. 1-21. *Urocleidus dolorcsae* n. sp.—1. Haptor. 2. Ventral anchor. 3. Ventral bar. 4. Hook No. 1. 5. Dorsal anchor. 6. Dorsal bar. 7, 10 and 12. Dorsal bars. 8, 9 and 11. Ventral bars. 14, 16, 17 and 19. Cirri. 13, 15, 18 and 20. Accessory pieces. 21. Ventral anchor.

Figs. 22-29 and 36-42. *Octomacrum microconfibula* n. sp.—22. Anterior end of worm. 23. Genital sucker. 24. Mouth. 25. Oral sucker. 26. Pharynx. 27. Egg *in utero*. 28. Haptoral hook, stretched out. 29. Haptoral hook, natural. 36. Genital sucker. 37. Egg 38a. Clamp. 38b. Ventral loop. 39. Dorsal loop. 40. *Center piece*. 41. Middle loop. 42. Genital sucker, different specimen.

Figs. 30-35. *Octomacrum lanceatum* Mueller, 1934.—30. Clamp. 31. Ventral loop. 32. *Center piece*. 33. Dorsal loop. 34. Middle loop. 35. Muscular lip of clamp.

All figures were drawn with the aid of a camera lucida, and the scales near the figures are ruled in mm.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Flood-Plain Animal Communities

Carlos C. Goff*

Not until recent years have studies been made of biotic communities. Shelford's work (1913), was one of the earliest on animal communities in relation to plants and other environmental factors. More recently, interest has been taken in this work, especially by zoologists. The interrelations of animal and plant communities have been shown by Cameron (1917), Watt (1923), Weese (1924), Blake (1926), Shackleford (1929), Smith (1928), and Bird (1930). Some plant ecologists have been reluctant to take animal effects on community and plants into consideration but fortunately this is not true of all. Vestal (1913) states, "Plant and animal associations are co-existent and to a large extent interdependent, the animals being entirely dependent upon the plants, broadly speaking, and the plants being partly dependent upon the animals."

The purpose of this work carried on between September 1928 and September 1929, was to study the biotic communities of the flood-plain sere, to trace the stages in their development, and correlate the successions of animal life with those of plant life.

Description of Country

This study was carried on about a mile and a quarter northeast of White Heath, Piatt County, Illinois, in the vicinity of the Illinois Central Railroad bridge over the Sangamon River. The hills near the Sangamon are low—generally not more than forty or fifty feet high. The neighboring country is fairly level, although somewhat broken for a half mile on each side of the river due to the valleys of tributaries. The river valley varies from a hundred yards to a half mile across, and is covered with timber where it has not been cleared. Originally the upland was oak hickory forest for a half mile or less on either side of the river where it merged with the prairie.

In the immediate region of the study the flood-plain soil is brown mixed loam, for the most part quite sandy in the early floodplain stages and containing more humus in the higher stages. It is not as stable as the upland timber soil, since at each flooding a new layer of sediment may be laid down or some material removed. The upland timber soil is reddish brown silt loam on drift or brownish gray silt loam.

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* It is regretted that Mr. Goff died in January, 1939. Shortly before his death he sent me a condensed copy of his thesis, which was nearly ready for publication. One table required condensation, and Fig. 1 had to be drawn. Due to pressure of administrative duties at that time, the paper was laid aside and overlooked until 1948. I have since condensed the manuscript, omitting detailed material which would be impractical to publish. Those persons desiring further details will find the original thesis in the University of Illinois library.—V. E. Shelford.

CLIMATE

The nearest weather station is at Urbana, Illinois, about 18 miles to the east of the study area; there is probably little difference in the climates of the two locations. The precipitation for 1928 was 33.06 inches, and for 1929, 44.20 inches; the excess over 1928 fell in April May, and July of 1929.

The amount of flooding of the flood-plain is, of course, directly dependent on the amount of rainfall. Most of the area about the Sangamon is under cultivation and well drained, and a considerable part of it is tiled, so that the river rises rapidly to a great height during rainy periods. During the period of study the highest flood-plain stage was submerged under two to three feet of water three times.

At the time of one of these floods in the first part of February the temperature dropped, freezing ice to about four inches thick. As the water went down, the ice settled, greatly damaging the shrubs and young trees. In one uncultivated field grown up with shrubs and small trees nearly every plant had some of its branches broken, or even had the main stem split or snapped off. On February 10, when the air temperature was -8°C., the soil temperature at a depth of two inches in the upland timber was -3°C, while in the flood-plain covered with ice the soil temperature was 0°C.

METHOD OF STUDY

This study was made by taking quantitative samples and by cruising. Data on plants were gathered mainly by the latter method, with tree counts to determine percentages of the individuals of the different species constituting the forest; study of the invertebrates was made chiefly by quantitative samples. Because of time limitations and an inadequate method of transportation, as well as the frequent flooding of the power flood-plain stations, it was not possible to make these collections at regular intervals or from all stations at the same time.

A metal cylinder was used to take samples from the herb and ground strata. It was 30 inches in height and 14.13 inches in diameter covering an area equal to 1/40,000 of an acre, or 1/100,000 of a hectare. It was fitted with a movable collar eight inches deep, and the upper end was closed except for a small opening with a removable plug.

The open end of the cylinder was driven into the ground over the area from which a sample was to be taken, and cyanide or ether was poured through the hole in the upper end. The cylinder remained in position until the animals became inactive. It was then removed, and the collar was left in the soil, definitely marking the area and preventing other animals from invading. Herbs and material from the ground surface were placed in one bag and the upper two inches of the soil in another. Although organisms go below this depth, studies made at the Rothamstead plots showed that most of the animals are found in the upper three inches of soil. Dr. Bird, in his work in Manitoba, found that very few animals go below a depth of two inches. The greatest loss by this method is of the earthworms which, especially in dry weather, go to a much greater depth.

Sweepings were made from the shrub and herb strata with a twelve-inch net. The average length of the sweep and the efficiency were estimated. Five long sweeps, taken at some distance from each other, were estimated to collect the animals in one square meter. After the height of the shrubs and herbs and the area covered by them were determined, a fairly accurate estimate of the number of animals per acre could be made (Beall, 1935).

Animals were removed from the soil by the use of the Morris soil washer. All but the smallest organisms were obtained in the screens after the soil had been washed through.

DESCRIPTION OF AREA STUDIED

Seven stations, illustrating the successive stages of community development, were selected for the study; the first six in the flood-plain, and the last in the upland forest. The common names of trees are those used in Miller & Tehon (1929) and the other plants are those used in *Gray's Manual*.

STATION 1. *Bare Ground-Heterocerus-Bledius associes.*—This station was selected to represent the first stage in the development of the flood-plain. For the greater part of the year this area is flooded, and during the period of study it was free of water only short times in May, August, and again in September and October, so that vegetation was unable to grow except in the late fall, when small seedlings started before frost. The soil is mostly sand overlaid with a layer of sediment, which furnishes a habitat during the fall for mud-living beetles (*Heterocerus*), and rove beetles (*Bledius*), which as scavengers find food in this debris.

STATION 2. *Bidens-Rumex-Helodrilus associes.*—The second stage of development varies greatly in different locations. In some areas the first plant to invade the bare ground is the willow; in others, a consocies of giant rag weed (*Ambrosia trifida*); in another situation the dominant plant is *Bidens comosa*. It was this latter type that was selected for study. The only other plants present are *Rumex brittanica*, second in importance, and *Aster* sp. (probably *paniculatus*). The area is about eighteen inches above the first station and is flooded rather frequently so that none of the plants mature enough to produce seed.

STATION 3. *Maple-Willow-Helodrilus associes.*—The third stage in the sere is characterized by willow and maple, the willow being somewhat the more abundant. The trees are close together, forming a thicket. Some of the willows are fairly large while the maples are small, indicating that the willows are the older and therefore the first invaders. One sycamore is present in this area. There are only two species of herbs, and these are much retarded in growth due to frequent flooding and dense shade. *Aster* sp. is the more abundant herb, the other being the false dragon head, *Physostegia virginiana*.

STATION 4. *Soft Maple-Young Elm-Helodrilus associes.*—The fourth stage in the succession is an island at high water. The island itself is flooded a little less than Station 3 and the soil is quite simliar.

The dominant tree is soft maple. The numbers of trees per acre were 162 soft maples, of from one to two feet in diameter, 27 sycamores of about the same size, and 230 elms (principally two species) with diameters of from two to six inches. No true shrubs are present but sweepings were taken from shrub-size young elms, and a few young hackberries and ashes. The only herb of any abundance is *Aster paniculatus*. This is probably the same aster that is present at Stations 2 and 3, but in both of these stations no plants reach a flowering stage, while in Station 4 the plant has more favorable growth conditions and produces flowers. Even in this station, however, much of the ground is bare of herbs.

STATION 5. *Elm - Bur Oak - Helodrilus - Succinea associes.*—Station 5 is from four to five feet higher than Station 4 and was flooded only three times during the year studied. A tree count in a fairly typical area gave these numbers per acre:

Tree	No. per acre	Per cent
American Elm	40	31.5
Pignut	16	12.5
Hackberry	16	12.5
Bur Oak	12	9.45
Crategus	12	9.45
Ash	8	6.30
Slippery Elm	8	6.30
Honey Locust	4	3.15
Redbud	4	3.15
Linden	4	3.15
Flowering Dogwood	4	3.15

The American elm is dominant due to size and abundance. Although in this particular area the bur oak is outnumbered by both pignut and hackberry, it is probably the more abundant and second in dominance of the flood plain trees of this stage. Hackberry is quite typical, but not generally abundant. The cottonwood tree is another typical flood-plain tree found in this stage, although scarce in this region.

In the shrubby growth there are cat briar, redbud, *Crategus*, young elm, hackberry, poison ivy, and grape. Young elms are especially abundant, but large numbers of these are crowded out in competition.

During the spring and early summer, buttercups, violets, wild onions, *Trillium*, nettles, sweet william, and grasses are the principal herbs; during the later summer and fall *Ranunculus septentrionalis*, wood nettles, and grasses are the outstanding plants.

STATION 6: *Elm-Shingle Oak-Henlea associes.*—This station was selected to represent an old, or high, flood-plain. It is two or three feet higher than Station 5, less sandy, and contains more humus than the preceding stations. The following tree count shows a decided difference from Station 5:

Tree	No. per acre	Per cent
American Elm	72	34.42
Shingle Oak	36	18.16
Pignut & Shagbark Hickory	34	16.25
Walnut	10	4.78
Redbud	10	4.78
Red Oak	10	4.78
Slippery Elm	10	4.78
Mulberry	10	4.78
Basket Oak	5	2.39
White Oak	5	2.39
Hackberry	5	2.39

This list shows a decided invasion of upland trees, represented by the oaks and hickory, which are typically upland trees, although elms are still most abundant.

The shrubs are practically the same as in Station 5. The principal herbs of the spring and early summer are waterleaf, *Claytonia virginica,* blood-root, *Trillium,* violets, *Dentaria,* and wild ginger. During the late summer, the outstanding herbs are *Ranunculus septentrionalis,* rye grass (*Elymus canadensis*), and *Rudbeckia laciniata.*

TABLE 1.—Comparison of the numbers of the species of invertebrate animals taken in the different stages within the communities studied and number of individuals per collection for earthworms and mollusks.

Station	1	2	3	4	5	6	7
Earthworms	0	2	2	2	3	6	2
Snails and slugs	0	0	0	1	9	5	5
Spiders	1	6	15	18	20	27	26
Centipedes and millipeds	0	0	0	0	2	5	5
Hemiptera	0	1	6	5	6	6	11
Homoptera	0	4	15	12	13	19	20
Coleoptera	8	20	24	31	31	49	80
Diptera	1	10	18	16	15	14	13
Formicidae	1	1	1	1	1	3	13
Miscellaneous	1	2	3	7	9	9	14
Total Species	12	46	84	93	109	143	189
Earthworm individuals	0	45	70	85	151	73	70
Mollusk	0	0	0	1	20	2	1

STATION 7. *Oak-Hickory-Fridericia-Formicidae association.*—Station 7 was in the upland woods and there possibly is some question as to whether or not it properly belongs in the flood-plain sere as the final stage. In Station 6 are certain trees which are typical of the upland forest, so that it seems justifiable to consider the upland climax forest as the final stage in flood land development. In the area studied the following tree count was made:

Tree	No. per acre	Per cent
Red Oak	39	20.8
White Oak	33	17.6
Pignut & Shagbark Hickory	30	16.0
American Elm	27	14.4
Slippery elm	15	8.0
Walnut	15	8.0
Black Oak	6	3.2
Bur Oak	6	3.2
Q. Prinus	3	1.6
Redbud	3	1.6
Mulberry	3	1.6
Honey locust	3	1.6
Black cherry	3	1.6
Sassafras	3	1.6

The shrubby growth is composed of young redbud, sassafras, and other saplings. The herbs of spring and early summer are *Claytonia,* May apples, Dutchman's breeches, blood root, waterleaf, *Trillium,* and grasses. Later the outstanding herbs are wood nettle, jewel weed, *Aster drummondi,* and goldenrod.

INVERTEBRATES

To name accurately the predominant or seasonal animals of a community would necessitate a study over a period of years, since there is a great change from year to year due to weather conditions, parasites, predators, diseases, etc. Thus the predominants named from the data for the year studied may hold a lesser place in another year. In the case of this study, the number taken were too small to be significant. The number of species of the large group is more important in this case, except for a few groups in the ground stratum.

The inhabitants of the ground stratum seem to be much more stable than those of the tree and herb stratum. This is probably due to a number of factors: in some ways the soil environment is more stable; soil temperatures are not so variable or extreme as air temperatures; amount and intensity of light is nearly constant; air currents, such as wind, do not occur. One factor which may vary greatly in a short time is the water content of the soil. After a heavy rain, the soil inhabitants are in a more or less aquatic condition which may last from only an hour or two up to several days, although this does not seem greatly to affect these invertebrates. Soil forms were taken at flood-plain stages just after long periods of flooding, and since many of these are not capable of migration, they were present during the flood. One of the outstanding groups with regard to abundance of individuals is the earthworms. They show a decided specificity as to habitat. Figure 1 shows their distribution in the stations.

The number of species of animals varies greatly in the stations. There is a progression in number from the lowest stage to the upland forest. Table 1 shows the number of species of invertebrates taken in the different stations during this study together with the average number of individuals per 0.1 m^2 for the earth worms and mollusks.

VERTEBRATES

The American toad (*Bufo americanus* Holb.) was observed in Station 5. The eggs of this species are laid in the shallow, quiet waters of the streams and ponds and during the latter part of the summer small toads are sometimes found in abundance near the water.

On November 18, one specimen of the leopard frog (*Rana pipiens* Sch.) was found in hibernation at Station 5. It had dug out a small hole under the leaf mold and was covered with a two or three inch layer of leaves and debris. At that time it was five feet above the water level of the river which was about forty yards away.

One reptile, *Thamnophis radix* (Baird and Girard), was found in Station 5 trying to swallow a leopard frog. Snakes of the genus *Natrix* are also found along the streams and are confined wholly to the early flood-plain stages near water.

The muskrat and mink are probably the only mammals that belong only to the flood-plain, and occasionally the mink may be found at some distance from streams according to Wood (1910). Both of these animals are trapped along the Sangamon, although the mink is somewhat rare. The muskrat, especially, is found only near the streams, its burrows made in the stream bank.

The gray squirrel is the predominant member of flood-plain communities. Several nests per mile were observed along the river. The gray squirrel is replaced by the fox squirrel in the upland timber, although it is not so abundant. These two animals are not absolutely confined each to the different type of woodland, but they seem to show decided preferences. They are probably responsible to some extent for the invasion of such trees as the oaks and hickories into flood-plains by helping in the distribution of seed. It has

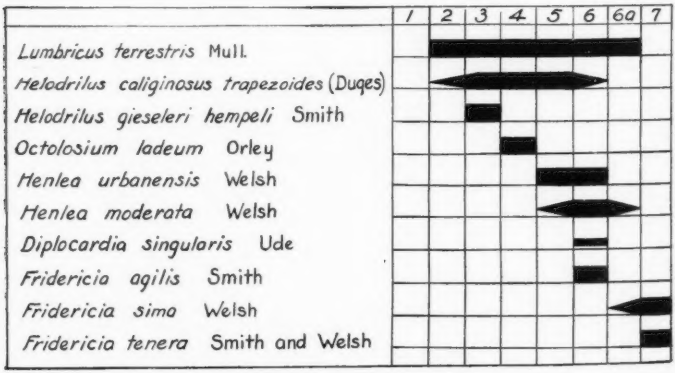

Fig. 1.—Showing succession of earthworms on the Sangamon flood plain near White Heath, Illinois

been observed that squirrels burying nuts and acorns short distances beyond the forest edge help in the invasion of the prairie by the forest.

The cottontail rabbit is a forest edge animal and during the warmer seasons of the year is found mostly in the open. However, in the winter, they go somewhat deeper into the woods in search of shelter. They were found in winter fairly abundantly in Stations 5, 6, and 7. In this area, however, where the woods form only a narrow strip along the river, they are never a great distance from the forest edge.

Skunk, opossum, and raccoon are found in both upland forest and flood-plains, tracks of the latter being observed along the stream at different times.

On one occasion in the spring a striped chipmunk was observed trapped by the high water on Station 3.

Birds range through all of the stages, and are not confined to any one of them. They take a heavy toll of the invertebrates. Woodpeckers, the chief enemies of wood borers, probably form the most abundant group of permanent residents, with the hairy first in number, followed by the red-bellied and the downy. The red-headed is also present throughout the year. Flickers are present throughout the year but decline in number in winter. Other permanent residents are white-breasted nuthatches, which are confined more to flood-plain than upland timber, crows, red-shouldered hawks, and barred owls. The latter was rather common and an important factor in the lives of the small mammals.

From the middle of March and through to the middle of May, spring migrant birds are found. Important members of this group are the robin, olive-backed thrush, oven-bird and warblers.

Summer resident birds are the indigo bunting, the wood pewee, and the red-eyed vireo, the latter often nesting in a pure stand of soft maple. The kingfisher also nests in the banks of the river, taking its food from the stream.

The junco is a winter resident, though it is more numerous from about the fifteenth of February to the latter part of April.

CONCLUSIONS

With the development of the flood-plain there is a succession of biotic communities.

There is a uniform progression in species from the lower stages to the highest but there is not a uniform progression in the number of individuals per unit area, though the tendency is for larger numbers in the higher stations, the climax stage having more than any preceding stage.

The animal population is made up of: a) permanent nucleus of invertebrates and vertebrates; b) seasonal invertebrates; and c) seasonal birds and rabbits (in winter).

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* Dr. L. L. Neave worked on earthworms and spiders with Dr. H. J. Van Cleave who states that he was an exceptional man and did reliable work. Soon after receiving his Ph.D. degree (major Chemistry) he went to the far North, has never been heard from again and is supposed to have perished. He never published on the forms which he identified.

Type Localities of Vascular Plants First Described from Illinois

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Introduction

The purpose of this study is to endeavor to advance in a small way the knowledge and understanding of eastern North American botany, particularly of the plants of Illinois, by assembling relevant data on type localities of vascular plants first described from this state. The "type locality" is the station where the holotype, or type specimen, was collected. Similar studies have been made for New Mexico by P. C. Standley (Contr. U. S. Nat. Herb. 13: 143-246, 1910), and for West Virginia, (Torreya 36: 7-13, 1936), by E. L. Core. The total number of names of vascular plants listed in this present paper as having been described from Illinois is 306; of this number 67 are regarded as representing valid species. Seventy different authors have described supposedly new taxons from Illinois. Of these, F. A. J. von Wangenheim was the first in 1787 to attribute a new species (*Carya illinoensis*) to Illinois. In 1793, André Michaux discovered 52 valid species in this state. E. L. Greene described 11 species, and G. Engelmann and A. Gray each contributed nine species.

The plan of this paper is as follows: Species and other taxons are arranged alphabetically in families, which follow the well-known Englerian sequence. The binomial or trinomial is cited as originally published. This is followed by the name of the author, abbreviated if of more than one syllable, and the place of original publication. In a few instances in which the actual date of publication differs from the ostensible date, the former is included in brackets. The statement of type locality is given as definitely as possible, usually as originally published, and then quoted directly, or in other examples a summary or abbreviation has been made. Whenever practicable the type collection has been cited by locality, number, date, and name of collector. The currently accepted nomenclatural designation and taxonomic interpretation have been indicated by a binominal at the end of the paragraph, except for some Rafinesquian names impossible to place.

Authentic material in the form of the holotype, isotypes or paratypes of the collections of H. H. Babcock, C. F. Baker, M. S. Bebb, H. C. Benke, Agnes Chase, V. H. Chase, I. W. Clokey, F. S. Earle, S. A. Forbes, G. H. French, F. C. Gates, C. Geyer, H. A. Gleason, E. L. Greene, J. M. Greenman, E. J. Hill, O. E. Lansing, F. E. McDonald, S. B. Mead, E. J. Palmer, H. N. Patterson, Norma Pfeiffer, R. Ridgway, R. A. Schneider, J. Wolf, et al., have been examined, chiefly in the herbarium of the University of Illinois and the Chicago Natural History Museum. The collections of A. Michaux in the Muséum d'Histoire Naturelle at Paris have not been studied by me. The seventy or more binomials of Rafinesque would have been the cause

of even more trouble had it not been possible to lean heavily on the recently published and invaluable *Index Rafinesquianus* of E. D. Merrill. Sargent's two dozen proposals in *Crataegus* are based chiefly upon collections of E. J. Hill, whose herbarium is the property of the University of Illinois. Although holotypes of proposed species of *Crataegus* based upon Hill's collections from northern Illinois are in the herbarium of the Arnold Aboretum, isotypes, paratypes, and additional specimens, usually in a good series of flowering and fruiting material, are conveniently available in the herbarium of the University of Illinois.

It is hoped that this annotated list of type localities of Illinois vascular plants may help to fix the application of certain binomials (and trinomials), and will draw attention of botanists to localities that provided original material. Thus will be facilitated the re-collection and distribution of topotype material from or near the original stations.

Thanks are due to Dr. V. H. Chase for several helpful suggestions; and Mrs. Shirley Beym for assistance in preparing manuscript.

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Subphylum LYCOPSIDA
ISOETACEAE

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EQUISETACEAE

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Subphylum PTEROPSIDA
Class FILICINEAE
POLYPODIACEAE

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Class ANGIOSPERMAE
Subclass MONOCOTYLEDONEAE
POTAMOGETONACEAE

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Agrostis racemosa Michx., l.c. "*Hab.* in ripis sabulosis inundatis fluminis Mississipi." Muhlenbergia racemosa (Michx.) BSP.

Andropogon avenaceus Michx., op. cit. 1: 58. "*Hab.* in vastissimis pratis Illinoensibus."—Sorghastrum nutans (L.) Nash.

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Panicum praecocius Hitchc. & Chase in op. cit. 8: 206. *V. H. Chase* 649, dry bank near Wady Petra, Stark Co., June 30, 1900.

Poa pectinata Michx., op. cit. 1: 69. "*Hab.* in arvis Illinoensibus."—Eragrostis pectinacea (Michx.) Nees.

Poa reptans Michx., op. cit. 1: 69. "*Hab.* in arvis Illinoensibus.—Eragrostis Illinoensis." [Kaskaskia, Randolph Co.]—Eragrostis reptans (Michx.) Nees.

Poa sesleroides Michx., op. cit. 1: 68.—"Hab. in regione Illinoensi et in montosis Carolinae."—Tridens flavus (L.) Hitchc.

Poa wolfii Scribn. in Bull. Torr. Club 21: 228 (1894). Canton, Fulton County, J. Wolf in 1882.

Uniola latifolia Michx., op. cit. 1:70. "The locality as published is Allegheny Mountains, but the type specimen is from Illinois."—Hitchcock, Man. Grasses U. S. 978 (1950).

CYPERACEAE

Carex bebbii Olney ex Fern. in Proc. Am. Acad. 37: 478 (1902). Illinois, *M. S. Bebb*.

Carex gravida Bailey in Mem. Torr. Club 1: 5 (1889). "Northern Illinois, *Vasey, Bebb,* to Northwestern Iowa, *Cratty.*"

Carex gravida var. *laxifolia* Bailey in op. cit. 6. "Northern Illinois, *Bebb,* . . ."—Carex gravida Bailey.

Carex grayi var. *hispidula* A. Gray ex Bailey in Mem. Torr. Club 1: 54 (1889). Menard Co., *E. Hall.*—Carex grayii Carey.

Carex illinoensis Dewey in Am. Journ. Sci. II 6: 245 (1848). Augusta, Hancock Co., Dr. S. B. Mead.—Carex conoidea Schkuhr ex Willd.

Carex meadii Dewey in op. cit. 43: 90 (1842). "Found by Dr. S. B. Mead at Augusta, Ill."

Carex rectior Mack. in N. Am. Fl. 18: 261 (1935). Based upon *C. granularis* var. *recta* Dewey in Wood, Classbook (ed. 1861, p. 763), type from "southern Illinois and Louisiana."

Carex richardsonii f. *exserta* Fern. in Rhodora 44: 290 (1942). Augusta, Hancock Co., *S. B. Mead.*—Carex richardsonii R.Br.

Carex straminea var. *meadei* Boott, Illustr. Gen. Carex 121, pl. 389 (1862). Type from Illinois.—Carex bicknellii Britt.

Carex subimpressa Clokey in Rhodora 21: 84 (1919), based on *C. impressa launginosa* Clokey in Torreya 16: 199 (1916); Cowford Bridge, Macon County, *I. W. Clokey* 2338.

Carex tribuloides var. *sangamonensis* Clokey in op. cit. 21: 84. "This well marked plant is found growing in rich alluvial soil in two small widely separated areas in Macon County, Illinois. My number 2364, preserved in my herbarium, is designated as the type. My number 2362 also belongs here."—Carex tribuloides Wahl.

Carex typhina Michx., op. cit. 2: 169. "*Hab.* in regione Illinoensi."

Cyperus wolfii Wood in Bull. Torr. Club 6: 72, January (1876); Bot. Gaz. 1: 38, July (1876). Anna, Union Co., John Wolf.—Cyperus ovularis (Michx.) Torr.

Eleocharis wolfii A. Gray ex Patterson, Cat. Pl. Illinois 46 (1876). "Margins of ponds, in very wet soil, Fulton County, Illinois, John Wolf."

Eriophorum tenellum Nutt. Gen., Additions (1818). "Illinois, Ohio, Pennsylvania."

Hedychloa fragrans Raf. ex Jacks. Ind. Kew. 1: 1100 (1893). *Hedychloe fragrans* Raf., Ann. Nat. Ann. Synop. 16 (1820). "from Illinois to Carolina."—Kyllinga pumila Michx.

Scirpus hallii A. Gray, Man. Bot. (ed. 2) add. (1863). "Along ponds, Mason Co., Illinois. . . . E. Hall." Error for Menard Co.

COMMELINACEAE

Larnalles glauca Raf. Fl. Tellur. 3: 71 (1836) [1837]. "Caule simplex, fol. glaucis lanceol. basi vaginatis, spatha term. subsess. cordata plicata—Kentucky, Illinois, pedal, flowers large pale blue."

Tradescantia barbata Raf. New Fl. N. Am. 2: 85 (1836) [1837]. ". . . Illinois and West Kentucky. . . ."—Tradescantia ohioensis Raf.

Tradescantia brevicaulis Raf. Atl. Journ. 1: 150 (1832), New Fl. N. Am. 2: 86 (1836) [1837]. "Illinois and Kentucky."—Tradescantia virginiana L.

PONTEDERIACEAE

Leptanthus ovalis Michx., op. cit. 2: 25. "*Hab.* in paludosis Illinoensibus."—Heteranthera limosa (Sw.) Willd.

JUNCACEAE

Juncus acuminatus var. *robustus* Engelm. in Trans. St. Louis Acad. 2: 463 (1866). "in the Mississippi Valley from Illinois, *Geyer, Mead, Vasey,* . . . to Missouri."—Juncus nodatus Coville.

Juncus interior Wieg. in Bull. Torr. Club 27: 516 (1900), 446 (1903). Richmond

[McHenry Co.] Vasey in Gray Herb.; type, between Urbana and Centralia (Vasey), Athens (E. Hall,—Junc. Bor. Am. Engelm. no. 21); Illinois Dr. Mead, no. 23."

Juncus vaseyi Engelm. in Trans. St. Louis Acad. 2: 448 (1866). "On the banks of Fox river, near Ringwood," (McHenry Co.).

LILIACEAE

Allium quinqueflorum Raf. First Cat. Bot. Gard. Transylv. Univ. 13 (1824) nom.; Herb. Raf. 63, nom., 64, descr. (1833). Illinois.—Allium sp.

Allium stenium Raf. Herb. Raf. 63, nom., 65, descr. (1833); Fl. Tellur. 2: 18, nom. (1836), as *Aglitheis stenia* Raf.; *Geboscon stenium* Raf., Aut. Bot. 60, descr. (1840). ". . . Illinois, fl. white vernal, scape pedal, leaves half size."

Trillium lirioides Raf. Am. Monthly Mag. Crit. Rev. 3: 356 (1818) nom.; First Cat. Bot. Gard. Transylv. Univ. 16 (1824) nom.; Med. Fl. 2: 100 (1830) descr; Aut. Bot. 134 (1840) nom., nota. "Near lake Erie, in the glades of Ohio, Illinois, &c."—Trillium sp.

Trillium membranaceum Raf. Med. Fl. 2: 98 (1830): "Glades of Kentucky, Illinois, and Missouri."—Trillium sessile L.

Trillium recurvatum f. *luteum* Clute in Am. Bot. 28: 79 (1922). ". . . A more interesting form is a yellow-green specimen of *Trillium reflexum* (sic) brought to our attention by Mrs. Everett Lewman. In this the petals are somewhat enlarged and leaflike and of a pale greenish-yellow. The claws of the petals are of the familiar brownish-red as are the stamens also. It is of course, only a color form, but to distinguish it we may call it *Trillium recurvatum* forma *luteum*." The type locality is not given, but is probably near Joliet, Will Co.

IRIDACEAE

Iris pallens Raf. New Fl. N. Am. 2: 93 (1836) [1837], nom. alt.; *Iris glumacea* Raf. var. *angustifolia* Raf., l.c. ". . . in the glades of Illinois, if a peculiar sp. it may be called *I. pallens*."—Iris sp.

BURMANNIACEAE

Thismia americana N. E. Pfeiff. in Bot. Gaz. 57: 123 (1914). "Chicago, Ill., in open prairie," *N. E. Pfeiffer*. Known only from the original collection. Type: Chicago Natural History Museum; isotype: University of Illinois. Discovered in August, 1912; now almost certainly extinct. Exact type locality recently located by Dr. Julian Steyermark, Chicago Natural History Museum, as follows: "Cook Co.: bottom prairie swale on east side of Calumet Lake, between Torrence Avenue (at about 11900 South) and Nickel Plate railroad, between Ford plant and Solway Coke plant, Chicago."

ORCHIDACEAE

Orchis glareosa Raf. Atl. Journ. 1: 150 (1832). ". . . in the glades of Illinois and W. Kentucky. . . ."—Habenaria flava (L.) R.Br.

Spiranthes petiolaris Raf. Herb. Raf. 45 (1833). Illinois.—Spiranthes sp.

Subclass DICOTYLEDONEAE

SALICACEAE

Salix eriocephala Michx., op. cit. 2. 225. "*Hab.* in regione Illinoensi."—Salix discolor Muhl.

Salix glaucophylla var. *angustifolia* Bebb in Rep. Nat. Hist. Northwestern Univ. 1889: 23 (1889). Chicago, *H. H. Babcock*.—Salix glaucophylloides Fern.

Salix imponens Gandoger, Fl. Europ. 21: 167 (1890). *Babcock*, Riverside, Cook Co.—Salix discolor Muhl.

Salix syrticola Fernald in Rhodora 9: 225 (1907). ". . . sandy shores of Lake Michigan, near Chicago, *H. H. Babcock*, 1880 (Bebb, Herbarium Salicum, no. 2) may serve as the type."—Salix adenophylla Hook.

JUGLANDACEAE

Juglans illinoensis Wang. Beytr. Nordam. Holz. 54 (1787). Illinois, but described from a tree cultivated at Flushing, New York.—Carya illinoensis (Wang.) K. Koch.

Juglans olivaeformis Michx., op. cit. 2: 192.—"*Hab.* in regione Illinoensium."—Carya illinoensis (Wang.) K. Koch.

FAGACEAE

×Quercus anceps E. J. Palmer in Journ. Arnold Arb. 29: 14 (1948). Rosiclare, Hardin Co.—Quercus imbricaria × falcata Schneck.

×Quercus bebbiana Schneider, Illustr. Handb. Laubh. 1: 201 (1904). Fountaindale, near Seward, Winnebago Co., *M. S. Bebb.*—Quercus alba × macrocarpa Engelm.

Quercus ellipsoidalis E. J. Hill in Bot. Gaz. 27: 204. pl. 2, 3 (1899), near Chicago.

×Quercus fernowi Trelease in Proc. Am. Philos. Soc. 56: 49 (1917). Based on *Q. alba* × *stellata* Engelm. in Trans. Acad. Sci. St. Louis 3: 399 (1877). Engelmann says "A specimen from the same careful observer (Bebb No. 24) must, I believe, be referred here. . . . Bark and flowers of Mr. Bebb's tree are unknown to me." Sargent (Silva N. Am. 8: 18, 1890) says "A tree discovered by Mr. M. S. Bebb, near Fountaindale, Illinois, shows some of the characters of *Quercus alba* and *Quercus minor* [*stellata*], and is believed to be a hybrid between these species." The type locality of ×*Q. fernowi* is, therefore, Fountaindale, Winnebago Co., but in view of the fact that one of the putative parents, *Q. stellata,* is not known to occur north of Adams and Mason counties, and that the northern limit of this species in Illinois is south of 41° N. lat., it seems extremely unlikely that ×*Q.fernowi* is a product of *Q. alba* × *stellata.*

Quercus nigra var. *tridentata* A.DC. in Prodr. 16 (2): 64 (1864). ". . . in Missouri prope St.-Louis." However, Engelmann in (Trans. Acad. Sci. St. Louis 3: 539, 1877 [1878], says, "A single tree, rather small, which was soon afterwards destroyed, was found by me in the autumn of 1849, on the hills 6 miles east of St. Louis. . . ." This locality is in Madison or St. Clair counties, Illinois.—× Quercus tridentata (A.DC.) Engelm.

Quercus prinus var. *tomentosa* Michx. Hist. Chen. Am. pl. 9, fig. 2 (1801), Fl. Bor. Am. 2: 196 (1803).—Type locality: "Cette variété croit en abondance aux Illinois, dans une vaste plain humide."—Michaux (1801). "In regions Illinoensi."—Michaux (1803). —Quercus bicolor Willd.

Quercus schneckii Britt. Man. Fl. N. States 333 (1901). Type from Mt. Carmel, Wabash Co., *Dr. J. Schneck.*—Quercus shumardii Buckl.

Quercus rubra β *runcinata* A.DC. in op. cit. 60. ". . . prope Saint-Louis, . . ." Bottomlands of the Mississippi River opposite St. Louis, i.e., Illinois, in Madison or St. Clair counties.—× Quercus runcinata (A.DC.) Engelm.

ULMACEAE

Celtis morifolia Raf. New Fl. N. Am. 3: 34, (1836) [1838]. "Found in Illinois, Kentucky &c. . . ."—Celtis occidentalis L.

Ulmus obovata Raf. New Fl. N. Am. 3: 38, (1836) [1838]. ". . . in Kentucky and Illinois. . . ."—Ulmus americana L.

SANTALACEAE

Comandra obtusifolia Raf. New Fl. N. Am. 2: 33 (1836) [1837]. ". . . Ohio to Illinois. . . ."—Comandra umbellata (L.) Nutt.

LORANTHACEAE

Viscum serotinum Raf. Ann. Gen. Sci. Phys. 5: 348 (1820). Isis von Oken 1821, 2: 977 (1821) descr.; First Cat. Bot. Gard. Transylv. Univ. 16 (1824) nom.; Med. Fl. 2: 275 (1830) nom.; New Fl. N. Am. 3: 22 (1836) [1838], descr. "Kentucky, Illinois, Missouri, &c. . . ."—Phoradendron flavescens (Pursh) Nutt.

POLYGONACEAE

Discolenta scabra Raf. New Fl. N. Am. 4: 48 (1836) [1838]; nom. alt. *Peutalis scabra* Raf. "In Kentucky, Illinois &c."—Polygonum lapathifolium L.

Polygonum ramosissimum Michx., op. cit. 1: 237.—"Hab. in regione Illinoensi."

Persicaria spectabilis Greene, Leafl. Bot. Obs. 1: 37 (1904). "Handsome species, known to me only as in U. S. Herb., in specimens by M. S. Bebb from Fountaindale [Winnebago Co.], and from Riley County, Kansas, by G. L. Clothier."—Polygonum coccineum Muhl.

CHENOPODIACEAE

Salsola platiphylla Michx., op. cit. 1: 174.—"*Hab.* in regione Illinoensium, huc alluvientibus Mississipi aquis alata."—Cycloloma atriplicifolium (Spreng.) Coult.

AMARANTHACEAE

Amaranthus ambigens Standl. in N. Am. Fl. 21: 106 (1917). "Type collected near Fountaindale [Winnebago Co.], by *M. S. Bebb* (U. S. Nat. Herb. 48297)."

CARYOPHYLLACEAE

Silene antirrhina var. *divaricata* B. L. Robins. in Proc. Am. Acad. 28: 132 (1893). Rockford, Winnebago Co., August, 1880, *M. S. Bebb, G. D. Swezey*—Silene antirrhina L.

ELATINACEAE

Elatine brachysperma A. Gray in Proc. Am. Acad. 13: 363 (1878). "Our specimens are mostly terrestrial; and are from Illinois, E. Hall, Texas, E. Hall, . . . A submersed or floating form, with narrower leaves was collected by M. S. Bebb in Illinois."

RANUNCULACEAE

Aconitum truncatum Raf. New Fl. N. Am. 1: 55 (1836). ". . . —In West Kentucky and Illinois, . . ." The only species of Aconitum attributed to Kentucky by Dr. E. Lucy Braun (Annotated Catalogue of Spermatophytes of Kentucky, 57, 1943) is *A. uncinatum* L., but we have no reports of its occurrence in Illinois.

Anemone caroliniana f. *violacea* Clute in Am. Bot. 28: 80 (1922).—In the vicinity of Joliet, Will Co. "It resembles the type in everything save the deep violet-colored flowers."

Delphinium carolinianum var. *crispum* L. M. Perry in Rhodora 39: 21 (1937). Based on coll. by H. A. Gleason at Milroy, Henderson Co., July 7, 1908 (GH).—Delphinium carolinianum Walt.

Ranunculus delphinifolius f. *rosiflorus* Clute in Am. Bot. 34: 106 (1928).—Type locality: Braidwood, Will Co.—Ranunculus flabellaris Raf.

Ranunculus fascicularis var. *deforesti* Davis in Minn. Bot. Studies 2: 470 (1900). Collected by Harry P. DeForest near Rossville, Vermilion Co., April 12, 1885.—Ranunculus fascicularis Muhl.

Ranunculus illinoensis Greene, Pittonia 5: 195 (1903). Collected at Alto Pass, Union Co., April 21, 1900, *C. F. Baker*.—Ranunculus fascicularis Muhl.

Trautvetteria palmata β coriacea Huth in Bot. Jahrb. 16: 288 (1892). Beardstown, Cass Co., *C. A. Geyer* in 1842.—Trautvetteria caroliniensis (Walt.) Vail.

NYMPHAEACEAE

Nuphar advena var. *brevifolia* Standl. in Rhodora 31: 37 (1929). Type from Big Creek, Richland Co., September 9, 1928, *R. Ridgway* 3351.—Nuphar advena Ait.

PAPAVERACEAE

Sanguinaria canadensis f. *colbyorum* Benke in Rhodora 35: 45 (1933). Crystal Lake, McHenry Co., May 1, 1932, *E. H. Colby*.—Sanguinaria canadensis L.

FUMARIACEAE

Corydalis aurea var. *micrantha* Engelm. ex A.Gray, Man. Bot., ed. 5, 62 (1867). "Illinois and St. Louis, *Riehl.*"—Corydalis micrantha (Engelm.) A.Gray.

SAXIFRAGACEAE

Heuchera cortusa Michx., op. cit. 1: 171, nom. illegit.=*H. americana* of auth. non L. quoad pl. Ill. "*Hab.* in variis locis Pensylvania, Carolinae, &c. frequenting in regione Illinoensi."—Heuchera richardsonii R.Br.

Heuchera richardsonii var. *grayana* Rosend., Butters & Lakela in Rhodora 35: 117 (1933). Type specimen in the herbarium of the Missouri Botanical Garden, collected by S. B. Mead at Augusta, Hancock Co., May, 1843.—Heuchera richardsonii R.Br.

Saxifraga forbesii Vasey in Am. Ent. & Bot. 2: 288 (1870). ". . . on shaded cliffs, near Makanda and Cobden, Southern Illinois.", *S. A. Forbes.*

ROSACEAE

Aruncus pubescens Rydb. in N. Am. Flora 22: 256 (1908). "Type collected in rich woods, Peoria, Illinois, in July, 1903, F. E. McDonald (Herb. N. Y. Bot. Gard.)." —Aruncus dioicus (Walt.) Fern.

Crataegus altrix Ashe in Bot. Gaz. 33: 232 (1902). "The type material was collected by the writer along streams and in pastures in northern Illinois."—Crataegus mollis (T. & G.) Scheele.

Crataegus apiomorpha Sarg. in op. cit. 35: 386. "Dry open places, wood borders and along the margins of the high banks of streams. Common and generally distributed in the neighborhood of Chicago. Mokena, July, 1900, May and September 1901, Barrington, May and September 1901, Glendon Park, May and September, 1901, Tinley Park, May and September 1901, Joliet, May and September 1902, *E. J. Hill;* Joliet, *H. C. Skeels,* May 1902, Fort Sheridan, May and September 1902, E. J. Hill."—Crataegus macrosperma Ashe.

Crataegus arduennae Sarg. in op. cit. 35: 377. Glen Ellyn, Du Page Co., *B. F. Gault,* June 1901; Forest of Arden, Joliet, Will Co., *E. J. Hill* in 1902.—Crataegus crusgalli L.

Crataegus assurgens Sarg. in op. cit. 35: 382. "River banks and woods in rich soil, Leyden township, May and September 1900, 1902, La Grange, June and September 1902, Thatcher's Park, May, September, and October 1901, May 1902, *E. J. Hill.*"—Crataegus pedicellata Sarg.

Crataegus coccinioides Ashe in Journ. Elisha Mitch. Sci. Soc. 16: 74 (1900). ". . . occurs along streams and in moist upland woods from southern Illinois to eastern Missouri.—The type material is preserved in my herbarium."

Crataegus corusca Sarg. in Bot. Gaz. 33: 117 (1902). Lake Zurich, Lake Co., Illinois. Collected by E. J. Hill.—Crataegus pedicellata Sarg.

Crataegus cyanophylla Sarg. in op. cit. 35: 387. "Dry upland pastures on the borders of woods, Mokena, September 1899, May 1900, Bremen and Orland, October 1901, May 1902, Joliet, May and September 1902, Oak Forest, September 1902, *E. J. Hill;* Joliet, *H. C. Skeels,* May 1902."—Crataegus macrosperma Ashe.

Crataegus egani Ashe in Journ. Elisha Mitch. Sci. Soc. 17: 15 (1900). "The type material, from northern Illinois, is preserved in my herbarium. . . . This species is named for Mr. W. C. Egan of Chicago, Ill."—Crataegus macrosperma Ashe.

Crataegus elongata Sarg. in Bot. Gaz. 35: 380 (1903). Deerfield, Lake Co., May 21, 1902, W. C. Egan, September 10, 1902, E. J. Hill.—Crataegus pedicellata Sarg.

Crataegus erecta Sarg. in op. cit. 31: 218, also in Ann. Rep. Missouri Bot. Gard. 19: 72 (1908). "Rich bottom-lands of the Mississippi river in Illinois opposite St. Louis."—Crataegus viridis L.

Crataegus ferrissii Ashe in Journ. Elisha Mitch. Sci. Soc. 17: 11 (1901). "Northern Illinois: J. H. Ferris; W. C. Egan."—Crataegus macrosperma Ashe.

Crataegus gaultii Sarg. in Bot. Gaz. 35: 397 (1903). "Open pastures, Milton Township, Du Page County, *B. T. Gault*, May and September 1902; Glen Ellyn, June 1902, bluff-like banks of Hickory Creek, Mokena, *E. J. Hill*, October 1900, May and June 1901."—Crataegus succulenta Schrad.

Crataegus grandis Ashe in Journ. Elisha Mitch. Sci. Soc. 17: 9 (1901). "Illinois: collected by me along the Wabash river, July 1899; C. F. Johnson: Freeport, Stephenson Co.; J. H. Ferriss: near Chicago."—Crataegus cuneiformis (Marsh.) Eggleston.

Crataegus hillii Sarg. in Bot. Gaz. 35: 384 (1903). "Open woods or near the borders of streams in moist rich soil, Thatcher's Park, September, 1899, May, August and September 1900, May and September 1901, Glendon Park, October 1900, woods by Des Plaines River, River Forest, May, June and September 1901, *E. J. Hill;* Thatcher's Park, *C. S. Sargent*, September 1900."—Crataegus pedicellata Sarg.

Crataegus illinoiensis Ashe in Journ. Elisha Mitch. Sci. Soc. 16: 76 (1900). Wady Petra, Stark Co., *V. H. Chase*. Dr. Chase (in lit., February 15, 1951) says: "When describing *Crataegus illinoiensis*, Ashe had in hand *Chase* 149 from tree no. 98, and *Chase* 150 from tree no. 53, both from S/W ¼ Sec. 30, Valley Tp., Stark Co., Illinois, collected October 21, 1897."—Crataegus succulenta Schrad.

Crataegus laxiflora Sarg. in Bot. Gaz. 35: 400 (1903). Banks of north branch of Hickory Creek at Marley, September 1895, upland pastures, Mokena, Will County, E. J. Hill in 1900 and 1901.—Crataegus succulenta Schrad.

Crataegus longispina Sarg. in op. cit. 35: 398. Lake Zurich, Lake Co., *E. J. Hill* & *C. S. Sargent* in 1900—Crataegus succulenta Schrad.

Crataegus lucorum Sarg. in op. cit. 31: 227. "Margins of oak groves in rich moist soil along the banks of sloughs near Barrington, Illinois, *E. J. Hill*, May and June 1899; *Hill* and *Sargent*, September 1900. *Crataegus macrosperma* Ashe.

Crataegus magniflora Sarg. in op. cit. 35: 383. "Borders of woods, in gravelly soil, Glendon Park, *E. J. Hill*, May, June, and September 1901."—Crataegus macrosperma Ashe.

Crataegus mitis Sarg. Man. Tr. N. Am. 407, pl. 326 (1905). "Low moist rich soil on the bottoms of the Mississippi River near the village of Kahokia [Cahokia], St. Clair County, Illinois."—Crataegus viridis L.

Crataegus nupera Ashe in Journ. Elisha Mitch. Sci. Soc. 19: 17 (1903). Joliet, Will Co., *W. W. Ashe* & *J. H. Ferriss*.—Crataegus mollis (T. & G.) Scheele.

Crataegus paucispina Sarg. in Bot. Gaz. 35: 391 (1903). "Woods and river banks in dry clay soil, Maywood, September 1899, May 1900, September 1901, May and September 1902, *E. J. Hill* and *C. S. Sargent*, September 1901."—Crataegus macrosperma Ashe.

Crataegus peoriensis Sarg. in op. cit. 31: 5. "In open woods along the moist borders of streams or depressions in the prairie and on hillsides in clay soil. Short [Stark] and Peoria counties, Illinois, where it was discovered by Mr. Virginius H. Chase of Wady Petra, Illinois, September 1897 (nos. 48, 446, 449, 481, 485)." Dr. Chase (in lit., Feb. 15, 1951) says "When Sargent was naming material from my tree no. 25 *C. peoriensis* I remonstrated that 90% of that form that I had sent him came not from Peoria Co. but from Stark Co. he replied that it was too late, the MS had already gone to press. I had always regarded my tree no. 25 as the type tree, it being the most convenient to my home and furnishing the bulk of the material sent to Sargent. Numbers 48 and 449 are from tree no. 25; 446 is from tree no. 84; 485 is from tree with no number. All these are from Stark County, but 481 is from Peoria County."—Crataegus cuneiformis (Marsh.) Eggleston.

Crataegus pratensis Sarg. in op. cit. 31: 6. "Open woods near the banks of small streams in the prairie region of Stark and Peoria counties, Illinois, where it was discovered by Mr. Virginius H. Chase in May 1898."—Crataegus punctata Jacq.

Crataegus ridgwayi Sarg. in Journ. Arnold Arb. 6: 2 (1925). ". . . common in open woods, growing on creek bottoms and dry uplands near Olney, Richland Co. . . . *R.*

Ridgway, May 14, 1921, April 29 and August 20, 1924 (Nos. 1375, 2087, and 2041, type)."—C. mollis (T. & G.) Scheele.

Crataegus schneckii Ashe in Journ. Elisha Mitch. Sci. Soc. 17: 8 (1900). Lawrenceville, Lawrence Co., in 1895, *J. Schneck.*—Crataegus viridis L.

Crataegus sextilis Sarg. in Bot. Gaz. 35: 390 (1903). "Near Lake Zurich, September 1899, May and September 1901; Thatcher's Park, May, August and September 1900, May and August 1901; Maywood, August 1900, May and August 1901; Beverly Hills, June and August 1901, June 1902; Oak Forest, September 1902, *E. J. Hill.*"—Crataegus macrosperma Ashe.

Crataegus subrotundifolia Sarg. in op. cit. 35: 394. Lake Zurich, Lake Co., and Honey Lake, Lake Co., *E. J. Hill* in 1901.—Crataegus pedicellata Sarg.

Crataegus tarda Sarg. in op. cit. 35: 392. Barrington, Lake Co., E. J. Hill in 1899, 1901, and 1902.—Crataegus macrosperma Ashe.

Crataegus trachyphylla Sarg. in op. cit. 35: 388. "Dry hills in clay soil, Mokena, September 26, 1900, May, June and September 1901, and May and September 1902, *E. J. Hill.*—Crataegus macrosperma Ashe.

Crataegus vegeta Sarg. in op. cit. 35: 396. "Oak woods in moist rich soil near the bank of the Calumet River, at Calumet [Cook Co.], *E. J. Hill,* May 27 and September 27, 1901; *C. S. Sargent,* September 1901."—Crataegus succulenta Schrad.

Crataegus viridis var. *nitida* Engelm. ex Britt. & Brown, Illustr. Fl. 2: 242 (1897). *Crataegus nitida* (Engelm.) Sarg. in Bot. Gaz. 31: 231 (1901). "Rich woods on the drier parts of the bottomlands of the Mississippi river opposite St. Louis, East St. Louis, Illinois, *G. W. Letterman,* June 10, 1881, and *H. Eggert,* 1882. Banks of Mississippi River, near Oquawka, Illinois, *H. N. Patterson.*"—Crataegus viridis L.

×Crataegus whitakeri Sarg. in Journ. Arn. Arb. 6: 3 (1925). "In an upland field of the Page Whitaker farm. Richland County, southeastern Illinois, *Robert Ridgway,* October 7, 1923 (No. 2057, type for fruit), June 2, 1924 (No. 2105, type for flowers)."

Geum canadense var. *camporum* f. *adenophorum* Fern. & Weatherby in Rhodora 24: 49 (1922). Rich woods, Peoria, July, 1904, *F. E. McDonald.*—Geum canadense Jacq.

Prunus hortulana Bailey in Gard. & Forest 5: 90 (1892). "This species appears to grow wild over a large part of our interior region from Kentucky and Illinois to Texas."

Rosa globosa Raf. Ann. Gén. Sci. Phys. 5: 215 (1820); Kentucky Gaz. 36 (32): (3) (1822) nom. Indiana, Illinois.—Rosa palustris Marsh.

Rosa illinoiensis E. G. Baker ex Wilmott, Genus Rosa 2: 243 (1911). La Salle Co., *Greenman, Lansing & Dixon* 133.—Rosa spinosissima L.

Rosa nivea Raf. Ann. Gén. Sci. Phys. 5: 218 (1820); Kentucky Gaz. 36 (32): (3) (1822) nom., nota. Illinois. (*Rosa rafinesquii* Seringe, 1825, non DC., 1817), sp. dubium.

Rosa pratensis Raf. Ann. Gén. Sci. Phys. 5: 215 (1820); First Cat. Bot. Gard. Transylv. Univ. 12 (1824) nom.; Kentucky Gaz. 36 (32): (3) (1822) nom. Indiana, Illinois, Kentucky.—Rosa carolina L.

Rosa relicta Erlanson in Rhodora 30: 116 (1928). "Residual prairie in Bliss Woods, Kane Co., July 30, 1925, *C. O. & E. W. Erlanson* 1533."—Rosa suffulta Greene.

Rubus offectus Bailey in Gent. Herb. 5: 186 (1941). "Kankakee County, eight miles east of St. Anne, in sandy swales with hazelnut bushes, *R. A. Schneider* 1661."

Rubus schneideri Bailey in op. cit. 5: 192. "Seven miles southeast of Momence, Kankakee County, growing in moss under *Nyssa sylvatica* in moist hollow between wooded sand hills, *Richard A. Schneider* 1689 (type), 1885, 1889."

Sorbus riparia Raf. Herb. Raf. 56, nom. (1833); New Fl. N. Am. 3: 15, descr. (1836) [1838]. ". . . growing on the margins of Rivers, the Missouri, upper Mississippi, lower Ohio, Wabash, Illinois; . . ." In Journ. Arnold Arb. 20: 25 (1939) I treated *Sorbus riparia* Raf. as a nomen dubium, listing it as a possible synonym of *S. decora* (Sarg.) Schneid. It is certain that no species of mountain-ash occurs naturally in south-

ern Illinois. The only Illinois species is *S. americana*, recorded from Oregon, Ogle County, on the basis of a collection by M. B. Waite in 1888.

LEGUMINOSAE

Chamaecrista camporum Greene in Pittonia 5: 108 (1903). Monticello, Piatt Co., Aug. 7, 1899, *E. L. Greene*.—Cassia fasciculata Michx.

Desmodium illinoense A. Gray in Proc. Am. Acad. 8: 289 (1870). "Illinois, in dry ground, Vasey, Hall, Bebb, Bergen, Stewart, &c."

Lespedeza capitata var. *stenophylla* Bissell & Fernald in Rhodora 14: 92 (1912).—Peoria, *F. E. McDonald* in 1904.—Lespedeza capitata Michx.

Lespedeza capitata var. *stenophylla* f. *argentea* Fern. in op. cit. 43: 579 (1941).—Havana, Mason Co., *H. A. Gleason* in 1903.—Lespedeza capitata Michx.

Lobomon acutifolium Raf. New Fl. N. Am. 1: 84 (1836). ". . . Ohio, Illinois &c. . . ."—Amphicarpa bracteata (L.) Fern.

Medicago sativa f. *alba* Benke in Amer. Midl. Nat. 16: 424 (1935). McHenry, McHenry Co., September 11, 1934, H. C. Benke 5665 (CM).

Mimosa illinoensis Michx., op. cit. 2: 254. "Hab. in pratensibus regionis Illinoensis."—Desmanthus illinoensis (Michx.) MacM. ex Robins. & Fern.

Petalostemum foliosum A.Gray in Proc. Am. Acad. 7: 336 (1868). "Banks of Fox River, Kane Co., Illinois, Burgess Truesdell, 1867."

Petalostemum purpureum f. *arenarium* Gates in Torreya 11: 127 (1911).—"Type: (Gates 2922) growing in sandy soil in the *Andropogon scoparius* consocies of the bunchgrass prairie at Waukegan, Lake County, Illinois, August 7, 1908. . . . Specimens may be consulted at the Herbarium of the University of Illinois, the Field Museum of Natural History in Chicago, (type) and the author's private herbarium."—Petalostemum purpureum (Vent.) Rydb.

Petalostemum violaceum Michx., op. cit. 2: 50. "*Hab.* in regione Illinoensi."—Petalostemum purpureum (Vent.) Rydb.

Phaseolus paniculatus Michx., op. cit. 2: 60—"*Hab.* in regione Illinoensi."—Phaseolus polystachyus (L.) BSP.

Trifolium reflexum var. *glabrum* Lojacono in Nuovo Giorn. Bot. Ital. 15: 150 (1883). "In Illinois prope Augustum (Dr. S. B. Mead!)"—T. reflexum L.

GERANIACEAE

Geranium pedatum Raf. Herb. Raf. 60, nom. (1833); New Fl. N. Am. 2: 34, descr. (1836) [1837]. "Glades and Prairies of West Kentucky and Illinois, semi-pedal, annual, flowers small purple vernal."

POLYGALACEAE

Polygala missurica Raf. New Fl. N. Am. 4: 89 (1836) [1838]." ". . . in the prairies of Missouri and Illinois. . . ."—Polygala cruciata L.

EUPHORBIACEAE

Chamaesyce lansingii Millsp. in Field Mus. Publ. Bot. 2: 376 (1913). Type from 56th St., Chicago, Aug. 6, 1898, *O. E. Lansing* 402 (CMNH).—Chamaesyce maculata (L.) Small.

Croton capitatus Michx. op. cit. 2: 214. "*Hab.* in regione Illinoensi."

Crotonopsis linearis Michx., op. cit. 2: 186, pl. 46, p.p. "*Hab.* in maritimis Carolinae, juxta *Long-Bay*, et in regione Illinoensi." "Two plants figured. One is a plant with lanceolate-linear leaves and slender spikes, the other with lanceolate to ovate-lanceolate leaves and flowers one to two together. As Illinois specimen certainly the latter, and as the former is known in the maritime region of Carolina, and is the plant to which the name *linearis* better applies, this is selected as the type."—Pennell, F. W., in Bull. Torr. Club 45: 479 (1918).

Euphorbia geyeri Engelm. & Gray in Boston Journ. Nat. Hist. 5: 260 (1847). Beardstown, Cass Co. Collected by C. A. Geyer in 1842. (MBG).—Chamaesyce geyeri (Engelm.) Small.

Heptallon capitatum (Michx.) Raf. Sylva Tellur. 65 (1838). ". . . Illinois and Missouri."—Croton captitatus Michx.

Heptallon graveolens Raf. Neogen. 1 (1825); Sylva Tellur. 65 (1838); Med. Fl. 2: 227 (1830) nom.; Aut. Bot. 47 (1840). "tomentosa, caule trichot. fol. petiol. ellipt. obt. integris, basi cordatis, fl. glomeratis.—Kentucky, Tennessee, Illinois &c., smell very peculiar nearly porcine."—Croton sp.

ANACARDIACEAE

Rhus valida Greene in Proc. Washington Acad. Sci. 8: 185 (1906). Hinsdale, Chicago, October 12, 1902, *E. C. Smith* 577 (CM). "I also refer here without hesitation Mr. O. E. Lansing's No. 1111, as in Herbarium Field Museum, from West Pullman, Ill., September 8, 1900."—Rhus glabra L.

Schmaltzia illinoensis Greene, Leaflets Bot. Obs. 1: 131 (1905). "This is a shrub of central Illinois represented in U. S. Herb. as collected by Dr. Brendel in 1878, near Peoria."—*Rhus aromatica* Ait.

Schmaltzia formosa Greene, op. cit. "Sandy woods at Cobden, extreme southern Illinois, 8 June, 1885, *M. B. Waite*—The locality is noted as that of a number of local species."—Rhus aromatica Ait.

HIPPOCASTANACEAE

Aesculus ochroleuca Raf. Alsogr. Am. 68 (1838). "Ohio, Kentucky, Tennessee, Illinois, &c. . . ."—Aesculus glabra Willd.

RHAMNACEAE

Rhamnus caroliniana var. *mollis* Fern. in Rhodora 12: 79 (1910). Type from Grand Tower, Jackson Co., by *G. Vasey* (GH).—Rhamnus caroliniana Walt.

VITACEAE

Ampelopsis cordata Michx., op. cit. 1: 159. "*Hab.* in dumetosis regionis Illinoensis et ad ripas amnis Savannah."

Vitis cinerea Engelm. ex Millardet, Etudes Vignes l'Amér. du Nord. 34 (1879). "Rich bottom lands in the Mississippi Valley, Illinois and southward."

Vitis glareosa Raf. Med. Fl. 2: 126 (1830); iter. Am. Man. Grape Vines 10 (1830). ". . . of the western glades or barrens, found from Illinois to Florida."—Vitis aestivalis Michx.

MALVACEAE

Iliamna remota Greene, Leafl. 1: 206 (1906). "Inhabits an island in the Kankakee River, Illinois, some twelve or fifteen miles above the city of Kankakee and just opposite a small village called Altorf; this is the only known locality for this species." First collected by E. J. Hill, June 29, 1872, as *Sphaeralcea acerifolia.* Collected on Aug. 1, 1899 by E. L. Greene, who described it as *Iliamna remota.* For recent study see E. E. Sherff in Rhodora 48: 89-96 (1946).

CISTACEAE

Lechea furfuracea Raf. New Fl. N. Am. 1: 92 (1836). ". . . In Kentucky and Illinois, . . ."—Lechea sp.

Lechea heterophyla Raf., op. cit. 93. ". . . Kentucky and Illinois in woods and glades. . . ."—Lechea minor L.

Lechea stricta Leggett ex Britt. in Bull. Torr. Club 21: 251 (1894). "On dry prairies, Illinois, Wisconsin and Iowa." Type (probably from Winnebago Co.): October 24, 1874, *M. S. Bebb* (NYBG).

VIOLACEAE

Viola falcata Greene, Pittonia 4: 3 (1889). In oak woods near Cobden, Union County, June 15, 1898, *E. L. Greene.*

Viola illinoensis Greene, op. cit. 4: 293 (1901). "This well marked woodland viole: of Central Illinois is common in rich open woods along the Sangamon River, near Monticello, and is here described from specimens which, transmitted thence to Washington in the autumn of 1899, have thriven and flowered with me during two successive seasons. There is no other violet with which to compare it as a very near relative, unless it be *V. affinis,* and it is far enough removed from that by many peculiarities."—Viola affinis Le Conte.

Viola perpensa Greene, Leafl. Bot. Obs. 1: 184 (1906). "The type specimens as to early state are on U. S. Herb. sheet 441,069 and were collected on a moist prairie at Dunning, near Chicago, Ill., 18 May, 1902, by Dr. H. S. Pepoon. There is another from Ottawa, Ill., by C. F. Johnson, May, 1889, and a third from low prairies, Dupage Co., Ill., by Dr. W. S. Moffatt; all these from the same region roundabout Chicago. But the plant was first known to me as seen and collected by myself at Dixon, Ill., from a low prairie, 18 June, 1898."

PASSIFLORACEAE

Passiflora lutea var. *glabriflora* Fern. in Rhodora 41: 436 (1939). Base of cliff between Sugar Loaf and Falling Spring, St. Clair Co., October 5, 1918, *J. M. Greenman* 3926.—Passiflora lutea L.

CACTACEAE

Opuntia rafinesquii Engelm. in Pac. R.R. Rept. 4: 41 (1856). Mississippi Valley, "Illinois, Missouri, Arkansas. . . ."

ONAGRACEAE

Oenothera canovirens Steele in Contr. U. S. Nat. Herb. 13: 365 (1911). Concord, Morgan Co., August 20, 1910, *E. S. Steele* (USNH).—O. strigosa (Rydb.) Mack. & Bush.

Jussiaea repens var. *glabrescens* Kuntze, Rev. Gen. Pl. 1: 251 (1891). "Cairo [am] Miss[issippi].," i.e., Alexander County.—Jussiaea diffusa Forsk.

Oenothera fruticosa f. *sessilicarpa* Levl. Mon. Onoth. 108 (1902). "A Geyer specimen is cited from Beardstown, Ill., and mention is made of the sessile capsules. This character and the locality would suggest *Oe. pilosella.*"—P. A. Munz in Bull. Torr. Club 64: 304 (1937).

CORNACEAE

Cornus lancifolia Raf. Alsogr. Am. 60 (1838); nom. alt., *Cornus serotina* Raf. "Illinois, Kentucky, Missouri in prairies. . . ."

UMBELLIFERAE

Cherophylum triflorum Raf. Herb. Raf. 79 (1833), Illinois.—Chaerophyllum procumbens (L.) Crantz.

Siumis heterophyla Raf. New Fl. N. Am. 4: 31 (1836) [1838]. "Found from New Jersey to Illinois. . . ."—Sium suave Walt.

Zizia sylvatica Benke in Rhodora 35: 45 (1933). Tunnel Hill, Johnson Co., September 5, 1931, *H. C. Benke* 5252 (CM).—Thaspium trifoliatum (L.) A. Gray.

PRIMULACEAE

Dodecatheon crenatum Raf. Atl. Journ. 1: 180 (1833); Herb. Raf. 28 (1833), "Illinois, . . ."; Aut. Bot. 186 (1840).—Dodecatheon meadia L.

Dodecatheon meadia f. *alba* Macbr. in Field Mus. Publ. Bot. 8: 129 (1930). "Prairie swale, Rockford, Winnebago Co., June 19, 1927, flowers white, *Macbride* 7073

(Type, Field Museum). Beach, Lake Co., May 26, 1918, flowers pure white, *Mrs. F. E. Pope.*"—Dodecatheon meadia L.

Dodecatheon meadia var. *frenchii* Vasey ex Wats. & Coult. in A. Gray, Man. Bot., ed. 6, 735b (1891). Type locality not stated, but a "specimen from 'Fern Rocks' near Makanda, Illinois, May, 1871, G. H. French in the Field Museum [Chicago Natural History Museum], has been marked 'Type,' presumably by Mr. Macbride, who has referred to it (in Field Mus. Publ. Bot. Ser. 8: 129-130, 1930). Vasey did not, as far as I can ascertain, designate a type, but it seems logical so to consider this sheet."—Fassett in Amer. Midl. Nat. 31: 471 (1944).—D. frenchii (Vasey) Rydb.

Dodecatheon meadia subsp. *membranaceum* R. Knuth ex Pax & Knuth in Das Pflanzenr. 237: 237 (1905). Based upon two collections from "southern Ill." One is from Makanda, Jackson Co., the type locality of *D. frenchii;* the other is from Fountaindale, Winnebago Co.—Dodecatheon frenchii (Vasey) Rydb.

Dodecatheon serratum Raf. Atl. Jour. 1: 179 (1833); Herb. Raf. 27 (1833). "Illinois." Aut. Bot. 185, nom. (1840).—Dodecatheon frenchii (Vasey) Rydb. (?)

Meadia crenata Raf. Aut Bot. 186 (1840). Illinois.—Dodecatheon meadia L.

Meadia longifolia Raf. in op. cit. 185. (*Dodecatheon longifolium* Raf.). "Kentucky, Illinois, Missouri, Louisiana. . . ."

Meadia serrata Raf. in l.c. Illinois.—Dodecatheon frenchii (Vasey) Rydb. (?)

OLEACEAE

Adelia ligustrina Michx., op. cit. 2: 224. Michaux gives the type locality of this species as : "*Hab.* in fruticetis Illinoensibus Tennassée, &c." although it is his second species, *Adelia acuminata,* "*Hab.* ad ripas fluviorum Carolinae et Georgiae" that occurs in Illinois. Perhaps the habitat lines in the two descriptions have been accidentally transposed. The illustration of *A. acuminata* (pl. 48) and the description of the fruit of *A. ligustrina,* "drupa breviuscule ovata" when compared with "drupa oblonga" for *A. acuminata,* indicate that *A. acuminata* is the Illinois shrub.

Borya cuneifolia Raf. Herb. Raf. 58 (1833) nom. Illinois.—Forestiera acuminata (Michx.) Poir.

GENTIANACEAE

Gentiana collinsiana Raf. Med. Fl. 1: 213 (1828). "In the glades of Indiana, Illinois, Missouri and West Kentucky."—Gentiana sp.

Gentiana serpentaria Raf. Ann. Nat. Ann. Synop. 13 (1820); First Cat. Bot. Gard. Tranyslv. Univ. 14, nom. (1824); Med. Fl. 1: 211, descr. (1828); iter. Man. Med. Bot. 211 (1841). "It grows in Indiana. . . ."—Ann. Nat. Ann. Synop. 13; "In Indiana, Illinois, &c."—Med. Fl. 1: 211.—Gentiana sp.

Gentiana shortiana Raf. First Cat. Bot. Gard. Transylv. Univ. 14, nom. (1824); Med. Fl. 1: 211, descr. (1828); iter. Man. Med. Bot. 211, descr. (1841). "Common in the glades of Kentucky, Tennessee, Illinois, &c."—Gentiana sp.

Gentiana torreyana Raf. First Cat. Bot. Gard. Transylv. Univ. 14, nom. (1824); Med. Fl. 1: 211, descr. (1828); Man. Med. Bot. 211, descr. (1841). "In the glades with the foregoing. . . ."—Gentiana sp.

ASCLEPIADACEAE

Asclepias meadii Torr. in A. Gray, Man. Bot. (ed. 2) 704 (1856). Augusta, Hancock Co., Illinois, *S. B. Mead.*

CONVOLVULACEAE

Anthanema capitata Raf. Fl. Tellur. 4: 90 (1836) [1838]. "Kentucky and Illinois."—Cuscuta sp.

Breweria pickeringii var. *pattersoni* Fernald & Schubert in Rhodora 51: 42 (1949).—Prairies near Oquawka, Henderson County, Illinois, August 10, 1873, *H. N. Patterson.*—Stylisma pickeringii (Torr.) A. Gray.

Cuscuta paradoxa Raf. Ann. Nat. Synop. 13 (1820); First Cat. Bot. Gard. Transylv. Univ. 13, nom. (1824). "In the barrens of Indiana and Illinois. . . ."—Cuscuta glomerata Choisy.

Cuscuta pentagona var. *microcalyx* Engelm. in Am. Journ. Sci. 45: 76 (1843). "Illinois."—Cuscuta pentagona Engelm.

Cuscuta saururi Engelm. in op. cit. 43: 339 (1842). "Margin of lakes and swamps, in the 'American Bottom' opposite St. Louis, on Saururus, where it was discovered in September, 1841, by my friend, Ch. Geyer. . . ."—Cuscuta gronovii Willd.

POLEMONIACEAE

Phlox bifida Beck in Am. Journ. Sci. 11: 170 (1826). "On the banks of the Illinois near Fort Clark." [Original site of present city of Peoria.]

Phlox pilosa var. *fulgida* f. *albiflora* (MacM.) Standl. in Rhodora 34: 176 (1932). —Type: Elgin, Kane Co., July, 1929, *C. F. Groneman.*

HYDROPHYLLACEAE

Hydrolea affinis A. Gray, Man. Bot., ed. 5, 370 (1867). "Banks of the Ohio in S. Illinois, *Dr. Vasey*, and of the Mississippi at Memphis, *A. Fendler:* also E. Texas, C. *Wright.*"

BORAGINACEAE

Onosmodium carolinianum var. *molle* A. Gray in Syn. Fl. 2(1): 206 (1878). "Illinois to Saskatchewan, Utah, and Texas."—Onosmodium occidentale Mack.

Onosmodium occidentale var. *sylvestre* Mack. in Bull. Torr. Club 32: 504 (1905). "The type was collected by Dr. Engelmann on July 21, 1861, in woods in the American bottom in Illinois opposite St. Louis, and is in the herbarium of the Missouri Botanical Garden."—Onosmodium occidentale Mack.

VERBENACEAE

Verbena bracteosa Michx. op. cit. 2: 13.—"*Hab.* in regione Illinoensi et in urbe Nash-ville."—Verbena bracteata Lag. & Rodr.

Verbena stricta Vent. Descr. Pl. Jard. Cels, pl. 53 (1800). ". . . découverte en 1792, par Michaux, dans le pays des Illinois, . . ."

LABIATAE

Blephilia lanceolata Raf. New Fl. N. Am. 4: 96 (1836) [1838]. ". . . in Kentucky, Indiana, Illinois. . . ."—Blephilia hirsuta (Pursh) Benth.

Brunella hirsuta Raf. Herb. Raf. 61, nom. (1833); New Fl. N. Am. 2: 30, descr. (1836) [1837]. ". . . Illinois and Missouri. . . ."—Prunella vulgaris L.

Koellia verticillata α *glabrior* Kuntze, Rev. Gen. 2: 520 (1891). "U.St.: Cairo, Miss.," i.e., Cairo, Alexander County, Illinois. Kuntze (op. cit., vol. 1, p. x) says "im September . . . nach Cairo am Mississippi [River] . . ."—This is listed by Grant & Epling (Univ. Calif. Publ. Bot. 20: 219, 1943) as a synonym of *Pycnanthemum verticillatum* (Michx.) Pers., a species which does not occur as far west as Illinois. Otto Kuntze's specimen is not in the herbarium of the New York Botanical Garden, but it probably belongs to *P. virginianum* (L.) Dur. & Jacks.

Lycopus americanus var. *scabrifolius* Fern. in Rhodora 47: 180 (1945). Havana, Mason Co., Aug. 15, 1903, *H. A. Gleason.*—Lycopus americanus Muhl.

Monarda virgata Raf. Med. Fl. 2: 37 (1830). "Prairies of Illinois and Arkansas." —(?) Monarda bradburiana Beck.

Scutellaria parvula Michx., op. cit. 2: 11. "*Hab.* in regione Illinoensi et Canada."

Scutellaria parvula var. *mollis* A. Gray in Proc. Am. Acad. 8: 630 (1873). "Oquawka, Illinois, on the sandy banks of the Mississippi, H. N. Patterson."—Scutellaria parvula Michx.

Vleckia albescens Raf. Aut. Bot. 121 (1840). ". . . Pennsylv. ad Illinois. . . ."—Agastache sp.

SOLANACEAE

Physalis pendula Rydb. ex Small, Fl. Se. U.S. 983 (1903). "In rich soil, Illinois to Kansas and Texas."

SCROPHULARIACEAE

Buchnera missurica Raf. Herb. Raf. 60, nom. (1833); New Fl. N. Am. 2: 32, descr. (1836) [1837]. ". . . Glades of Missouri and Illinois. . . ."—Buchnera americana L.

Capraria multifida Michx., op. cit. 2: 22, pl. 35. "'*Hab.* in ripis arenosis fluminum amniculorumque, in Tennasée et Illinoensi regione A. Michaux.' In Herb. Michaux at the Muséum d'Histoire Naturelle at Paris, France are two collections of this: one a single small plant labeled 'Kentucky'; the other a sheet of six good specimens labeled 'Illinois.' Both are the characteristic species so well depicted in Michaux's Flora, and the latter may be considered as the type." (Pennell in Acad. Nat. Sci. Phila. Monogr. 1: 104, 1935).—Leucospora mutifida (Michx.) Nutt.

Dasistema auriculatum Raf. New Fl. N. Am. 2: 67 (1836) [1837]. ". . . on the banks of R. Ohio in West Kentucky and Illinois. . . ."—Dasistoma macrophylla (Nutt.) Raf.

Gerardia auriculata Michx., op. cit. 2: 20. "*Hab.* in pratis regionis Illinoensis." Probably Wayne County, according to Pennell in op. cit. 417. Collected by A. Michaux, August 25, 1795.

Monniera rotundifolia Michx., op. cit. 2: 22. "*Hab.* in regione Illinoensi."—Bacopa rotundifolia (Michx.) Wettst.

Pedicularis lanceolata Michx., op. cit. 2: 18. "'*Hab.* in regione Illinoense.' Type labeled 'Illinois' and seen in Herb. Michaux at the Muséum d'Histoire Naturelle at Paris, France, is the species now considered. In August, 1795 André Michaux crossed southern Illinois from Post Vincennes (now Vincennes, Indiana) on the Wabash River to Kaskaskia, situated near the Kaskaskia River about two miles from its mouth in the Mississippi River in the present Randolph County, Illinois; the species is known from near the Wabash, and just to the north along the Mississippi River, portions of this course."—Pennell, op. cit. 493.

Penstemon glaucophyllus Scheele in Linnaea 21: 763 (1848). Type locality: "Illinois."—Penstemon digitalis Nutt.

Penstemon nuttalli Beck in Am. Journ. Sci. 14: 120 (1828). Type locality: "Illinois or Missouri."—Penstemon digitalis Nutt.

PLANTAGINACEAE

Plantago aristata Michx., op. cit. 1: 95. "*Hab.* in pratensibus Illinoensium."

Plantago atrofusca Raf. Atl. Journ. 1: 150 (1832); Herb. Raf. 61, nom. (1833); New Fl. N. Am. 4: 11, 12, nom. (1836) [1838]. ". . . in arid hills S. Illinois and W. Kentucky. . . ."—Plantago sp.

Plantago gonophylla Raf. First Cat. Bot. Gard. Transylv. Univ. 15, nom. (1824); Atl. Journ. 1: 18, nom., 149, descr. (1832); Herb. Raf. 61, nom. (1833) (*gonophyla*); New Fl. N. Am. 4: 12, nom. (1836) [1838] (*gonophyla*). ". . . Illinois and Ohio."—Plantago rugelii Dcne. (?)

RUBIACEAE

Galium circaezans var. *hypomalacum* Fern. in Rhodora 39: 450 (1937). Open dry woods, Peoria, July, 1903, *F. E. McDonald* (GH).—Galium circaezans Michx.

Galium setaceum Raf. Atl. Journ. 1: 17 (1832), non Lam. (1788). "Illinois. . . ."—Galium asprellum Michx.

CAPRIFOLIACEAE

Lonicera rupestris Raf. New Fl. N. Am. 3: 17 (1836) [1838]. ". . . on the lime

rocks of Kentucky and Illinois, rare, seen only in 3 localities, one at a Cave on the Elkhorn creek. . . ."—Lonicera prolifera (Kirchn.) Rehder (?)

Triosteum obovatum Raf. New Fl. N. Am. 2: 37 (1836) [1837]. ". . . from New York to Illinois, the most common sp. in the Western States. . . ."—Triosteum perfoliatum L.

Triosteum perfoliatum var. *illinoense* Wieg. in Rhodora 25: 202 (1923). Oquawka, Henderson Co., Illinois. Collected by H. N. Patterson.—Triosteum illinoense (Wieg.) Rydb.

Viburnum lanceolatum Raf. Herb. Raf. 57 (1833) nom.; Alsogr. Am. 56 (1838) descr. "Found in Illinois. . . ."

VALERIANACEAE

Fedia ciliolata Raf. New Fl. N. Am. 4: 68 (1836) [1838]; Aut. Bot. 88, nom. (1840). ". . . in Kentucky and Illinois."—Valerianella sp.

LOBELIACEAE

Lobelia cardinalis × siphilitica Schneck in Bot. Gaz. 3: 36 (1878).—Type locality: Mt. Carmel, Wabash County.

COMPOSITAE

Achillea occidentalis Raf. ex DC. Prodr. 6: 24 (1837), as synonym; Rydb. in Bull. Torr. Club 37: 456 (1910). Type locality: Illinois, acc. to Rydb.; "in America bor. frequens a Pensylvania ad reg. Illinoensem (Raf.!)."—DC., l.c.—Achillea millefolium L.

Ambrosia bidentata Michx., op. cit. 2: 182. "*Hab.* in regioni Illinoense."

Ambrosia bidentata × trifida A. Gray in Bot. Gaz. 11: 338 (1886). Type locality: St. Clair Co., *H. Eggert* in 1886.

Ambrosia coronopifolia T. & G. Fl. N. Am. 2: 291 (1842). "Prairies of Illinois."

Antennaria calophylla Greene, Pittonia 3: 347 (1898). "Very plentiful in open woods, among rocks, in the limestone region of southern Illinois, near Cobden, F. S. Earle, 30 March, 1879, male plant, in flower only; also the mature foliage from the same locality, collected by the present writer in June, 1898. . . ."—Antennaria fallax Greene.

Antennaria erosa Greene in Amer. Midl. Nat. 2: 78 (1911). Sandoval, Marion Co., Illinois, June 12, 1898, *E. L. Greene*.—Antennaria neglecta Greene.

Antennaria occidentalis Greene, Pittonia 3: 322 (1898). "Common in grassy openings among oak woods along the rivers of the Illinois prairie region, and apparently westward to Kansas."—Antennaria fallax Greene.

Aster anomalus Engelm.—"On limestone rocks, the brink of precipices, &c., in Illinois and Missouri, not uncommon, *Dr. Engelmann*."

Aster azureus f. *laevicaulis* Fern. in Rhodora 51: 94 (1949).—Type: Fountaindale, Winnebago Co., *M. S. Bebb* in 1867 (GH).—Aster azureus Lindl.

Aster ericoides f. *gramsii* Benke in Amer. Midl. Nat. 13: 328 (1932). Schiller Park, Cook Co., Sept. 23, 1949, *H. C. Benke* 4948 (CM).—Aster ericoides L.

Aster furcatus Burgess in Britt. & Brown, Illustr. Fl. 3: 358 (1898). "In woods, especially on shaded cliffs, Illinois and Missouri."

Aster furcatus var. *elaciniatus* Benke in op. cit. 326. Crystal Lake, McHenry Co., Sept. 2, 1928, *H. C. Benke* 4836 (CM).—Aster furcatus Burgess.

Aster hyssopifolius Raf. Atl. Journ. 1: 17 (1832). "In Illinois. . . ."—Aster sp.

Aster laevis × *paniculatus* Benke in op. cit. 327. McHenry, McHenry Co., Sept. 30, 1931, *H. C. Benke* 5280 (CM).—Aster laevis L.

Aster pilosus Willd. Sp. Pl. 3: 2025 (1804). "Habitat in America boreali in regione Illinoensium."

Aster puniceus var. *lucidulus* A. Gray, Syn. Fl. 1(2): 195 (1884). "Low ground, New England to Illinois, Wisconsin, and northward."—Aster lucidulus (A. Gray) Wieg.

Aster sericeus Vent. Descr. Pl. Jard. Cels, pl. 33, (1801). ". . . découverte par Michaux dans le pays des Illinois, sur les rives escarpées du Missouri et du Mississipi."

Aster shortii f. *gronemanni* Benke in Rhodora 31: 150 (1929). "Elgin (north part), Kane County, Oct. 1, 1928, *Benke* 4872." (CM).—Aster shortii Lindl.

Aster villosus Michx., op. cit. 2: 113, not Thunb. (1800). "Hab. in pratis illinoensibus."—Aster pilosus Willd.

Aster vimineus var. *subdumosus* Wieg. in Rhodora 30: 171 (1928). Type from Olney, Richland Co., *R. Ridgway* 68.—Aster vimineus Lam.

Boltonia asteroides f. *rosea* Benke in op. cit. 34: 9. Glencoe, Cook Co., *H. C. Benke* 4940.—Boltonia asteroides (L.) L'Her.

Boltonia diffusa var. *interior* Fern. & Grisc. in op. cit. 42: 490. De Soto, Jackson Co., Illinois, Aug. 1862, *G. Vasey*.—Boltonia diffusa Ell.

Boltonia glastifolia, published by Michx., op. cit. 2: 132, as a new species, "*Hab.* in regione Illinoensi," is a binomial dating from 1788, (Hill) L'Her.—Boltonia asteroides (L.) L'Her.

Boltonia latisquama var. *microcephala* Fern. & Grisc. in Rhodora 42: 492 (1940). Harvey, Cook Co., Aug. 30, 1893, S. H. Burnham.—Boltonia asteroides (L.) L'Her.

Cacalia pteranthes Raf. Ann. Nat. Synop. 14 (1820); First Cat. Bot. Gard. Transylv. Univ. 13, nom. (1824). "It grows in the barrens of Indiana and Illinois."—Cacalia tuberosa Nutt.

Chrysopsis camporum Greene, Pittonia 3: 88 (1897). "A most distinct prairie species, of apparently limited range in the middle Mississippi Valley, in southern Illinois and perhaps adjacent Missouri, also extending thence southeastward; apparently first collected by C. W. Short, and confused with *C. villosa*."

Cnicus hillii Canby in Garden & Forest 4: 101 (1891). ". . . sandy borders of Lake Michigan, Cook Co., Illinois." Collected by E. J. Hill in 1890.—Cirsium hillii (Canby) Fern.

Coreopsis aristosa Michx. op. cit. 2: 140. *Hab.* in regione Illinoensi."—Bidens aristosa (Michx.) Britt.

Coreopsis palmata Nutt. Gen. 2: 180 (1818). "On the open plains of the Michigan Territory, Illinois and Lower Louisiana."

Coreopsis tripteris var. *deamii* Standl. in Rhodora 32: 33 (1930). Henderson Co., *H. N. Patterson* in 1871.—Coreopsis tripteris L.

Coreopsis tripteris var. *intercedens* Standl. in op. cit. 32: 34. Edgewater, Chicago, *F. C. Gates* 808.—Coreopsis tripteris L.

Erigeron divaricatus Michx., op. cit. 2: 123. "Habitat in praetensibus Illinoensibus, prope Kaskaskia," Randolph Co.

Eupatorium coelestinum f. *illinoense* Benke in Rhodora 35: 46 (1933). Creal Springs, Williamson Co., Sept. 6, 1931, *H. C. Benke* 5272.—Eupatorium coelestinum L.

Euthamia media Greene, Pittonia 5: 74 (1902). Oquawka, Henderson Co., Sept. 1876, *H. N. Patterson*.—Solidago media (Greene) Bush, nom. provis.

Helenium traxilum Raf. New Fl. N. Am. 4: 82 (1836) [1838]; Aut. Bot. 54, nom. (1840). ". . . found in Indiana and Illinois. . . ."—Helenium sp.

Helianthus canescens Michx., op. cit. 2: 140. "*Hab.* in pratensibus irriguis regionis Illinoensis et Tennassée.—Helianthus mollis Lam.

Helianthus illinoensis Gleason in Ohio Nat. 5: 214 (1904). "On the sand dunes along the Illinois river near Havana, Mason Co., where it is common in the black-jack oak woods, especially along the edges and in the more open and sunny places. Material was collected in 1903 and 1904, and the type, collected on August 17, 1904, is in the herbarium of the Missouri Botanical Garden."—Helianthus occidentalis Riddell.

Helianthus tomentosus Michx., op. cit. 2: 141. "*Hab.* in pratensibus Illinoensibus." Erroneously attributed to Illinois.

Heliochroa linneana Raf. Neogen. 3 (1825) nom.—Brauneria purpurea (L.) Britt., fide E. D. Merrill, Ind. Raf. 237 (1949).

Hieracium scabrum var. *intonsum* Fern. & St. John in Rhodora 16: 183 (1914). Athens, Menard Co., *E. Hall* 35.—Hieracium scabrum Michx.

Laciniaria scabra Greene, Pittonia 4: 317 (1901). Pine Hills, Union County, Sept. 23, 1890, *F. S. Earle*.—Liatris scabra (Greene) K. Schum.

Laciniaria scariosa var. *strictissima* Lunell in Amer. Midl. Nat. 2: 177 (1912). Peoria, *F. E. McDonald*, August, 1904.—Liatris aspera Michx.

Laciniaria scariosa var. *subcymosa* Lunell in op. cit. 2: 177. Cook Co., *W. W.* Calkins, September 1876.—Liatris aspera Michx.

Liatris aspera Michx., op. cit. 2: 91. "*Hab.* in regione Illinoensi."

Liatris cylindracea Michx., op. cit. 2: 93. "*Hab.* in pratis sylvisque Illinoensibus."

Liatris pycnostachya Michx., op. cit. 2: 91. "*Hab.* in pratis Illinoensibus."

× Liatris ridgwayi Standl. in Rhodora 31: 37 (1929). East of Bethel Church, Richland Co., August 26, 1928, *Robert Ridgway* 3265. (CM).—Liatris pycnostachya × squarrosa.

Liatris spheroidea Michx., op. cit. 2: 92. "*Hab.* in pratis Illinoensibus et in excelsis montibus Carolinae."—Liatris aspera Michx.

Prenanthes aspera Michx., op. cit. 2: 83. "*Hab.* in pratis regionis Illinoensis."

Prenanthes crepidinea Michx., op. cit. 2: 84. "*Hab.* in regione Illinoensi et in excelsis montibus Carolinae."

Prenanthes ["*Prenantus*"] *spicata* Raf. Atl. Journ. 1: 150 (1832). ". . . Glades Illinois and Ohio. . . ."—Prenanthes aspera Michx.

Rudbeckia hirta f. *flavescens* Clute in Am. Bot. 21: 56 (1915). Oak Forest, Cook Co., *W. N. Clute*.—Rudbeckia hirta L.

Rudbeckia pinnata Vent. Descr. Pl. Jard. Cels, pl. 71 (1802). ". . . découverte par Michaux dans le pays des Illinois."—Ratibida pinnata (Vent.) Barnh.

Rudbeckia subtomentosa Pursh, Fl. Am. Sept. 575 (1814). "in regione Illinoensi."

Silphium integrifolium Michx., op. cit. 2: 146. "*Hab.* in regione Illinoensi."

Solidago emarginata Millsp. & Sherff in Field Mus. Publ. Bot. Ser. 4: 7 (1918).—"*I. F. Holton*, near Morris Illinois, September 13, 1850 (type Herb. University of Chicago, in Herb. Field Museum cat. no. 368080)."—Solidago speciosa Nutt.

Tagetes papposa Vent. Descr. Pl. Jard. Cels, pl. 36 (1800). "Illinois."—Dyssodia papposa (Vent.) Hitchc.

Tetraneuris herbacea Greene, Pittonia 3: 268 (1898). "Central Illinois and Ohio."—Actinea herbacea (Greene) B. L. Robins.

Verbesina helianthoides Michx., op. cit. 2: 135. "*Hab.* in occidentalibus alléghanis, territorio Tennassée, et regione Illinoensi."

Vernonia altissima var. *brevipappa* Gleason in Bull. Torr. Club 46: 248 (1919). Mt. Carmel, Wabash Co., Aug. 13, 1891, *J. Schneck* (ILL.)—Vernonia altissima Nutt.

Vernonia fasciculata Michx., op. cit. 2: 94. "*Hab.* in pratis Illinoensibus."

Vernonia illinoensis Gleason in Bull. N. Y. Bot. Gard. 4: 211 (1906). Champaign, *H. A. Gleason* 2865 (NY).—Vernonia missurica Raf.

Xanthium chasei Fern. in Rhodora 48: 66 (1946). Bottomlands of Illinois River in Tazewell Co., near Peoria, Illinois, October 1, 1919, *V. H. Chase* 3398 (type, GH), Sept. 12, 1920, *V. H. Chase*, 3474, Sept. 15, 1945, *V. H. Chase* 8205.

COUNTY INDEX

This list only includes those plants whose type locality is definitely known.

ALEXANDER—Jussiaea repens var. glabrescens, Koellia verticillata var. glabrior.

CASS—Atheropogon papillosus, Euphorbia geyeri, Oenothera fruticosa f. sessilicarpa, Trautvetteria palmata var. coriacea.

CHAMPAIGN—Vernonia illinoensis.

COOK—Aster ericoides f. gramsii, Boltonia asteroides f. rosea, B. latisquama var. microcephala, Chamaesyce lansingii, Cnicus hillii, Coreopsis tripteris var. intercedens, Crataegus apiomorpha, C. assurgens, C. hillii, C. lucorum, C. magniflora, C. paucispina, C. sextilis, C. vegeta, Laciniaria scariosa var. subcymosa, ×Potamogeton rectifolius, Quercus ellipsoidalis, Rhus valida, Rudbeckia hirta f. flavescens, Salix glaucophylla var. angustifolia, S. imponens, S. syrticola, Thismia americana, Viola perpensa.

DU PAGE—Crataegus arduennae, C. gaultii.

FULTON—Bromus purgans var. incanus, Poa wolfii.

GRUNDY—Solidago emarginata.

HANCOCK—Asclepias meadii, Carex illinoensis, C. meadii, C. richardsonii f. exserta, Heuchera richardsonii var. grayana, Trifolium reflexum var. glabrum.

HARDIN—× Quercus anceps.

HENDERSON—Breweria pickeringii var. pattersoni, Coreopsis tripteris var. deamii, Delphinium carolinianum var. crispum, Euthamia media, Potamogeton illinoensis, Scutellaria parvula var. mollis, Triosteum perfoliatum var. illinoense.

JACKSON—Boltonia diffusa var. interior, Dodecatheon meadia var. frenchii, D. meadia subsp. membranaceum, Echinochloa muricata var. occidentalis, Rhamnus caroliniana var. mollis.

JOHNSON—Zizia sylvatica.

KANE—Aster shortii f. gronemanni, Petalostemum foliosum, Phlox pilosa var. fulgida f. albiflora, Rosa relicta.

KANKAKEE—Iliamna remota, Rubus offectus, R. schneideri.

LAKE—Crataegus corusca, C. elongata, C. longispina, C. nupera, C. subrotundifolia, C. tarda, Petalostemum purpureum f. arenarium.

LA SALLE—Panicum lanuginosum var. siccanum, Rosa illinoiensis.

LAWRENCE—Crataegus schneckii.

MCHENRY—Aster furcatus var. elaciniatus, A. laevis × paniculatus, Juncus vaseyi, Medicago sativa f. alba, Potamogeton vaseyi, Sanguinaria canadensis f. colbyorum.

MACON—Carex subimpressa, C. tribuloides var. sangamonensis.

MARION—Antennaria erosa.

MASON—Helianthus illinoensis, Lespedeza capitata var. stenophylla, Lycopus americanus var. scabrifolius.

MENARD—Hieracium scabrum var. intonsum, Isoetes melanopoda, Scirpus hallii.

MORGAN—Oenothera canovirens.

PEORIA—Aruncus pubescens, C. pratensis, Galium circaezans var. hypomalacum, Geum canadense var. camporum f. adenophorum, Laciniaria scariosa var. strictissima, Lespedeza capitata var. stenophylla f. argentea, Phlox bifida, Schmaltzia illinoensis.

PIATT—Chamaecrista camporum, Viola illinoensis.

RANDOLPH—Erigeron divaricatus, Poa reptans.

RICHLAND—Aster vimineus var. subdumosus, Crataegus ridgwayi, C. whitakeri, Liatris ridgwayi, Nuphar advena var. brevifolia.

ST. CLAIR—Crataegus mitis, C. nitida, Cuscuta saururi, Onosmodium occidentale var. sylvestre, Passiflora lutea var. glabriflora.

STARK—Crataegus illinoensis, C. peoriensis, Panicum praecocius.

TAZEWELL—Xanthium chasei.

UNION—Antennaria calophylla, Cyperus wolfii, Laciniaria scabra, Ranunculus illinoensis, Schmaltzia formosa, Viola falcata.

VERMILION—Ranunculus fascicularis var. deforesti.

WABASH—Lobelia cardinalis × siphilitica, Quercus schneckii, Vernonia altissima var. brevipappa.

WAYNE—Gerardia auriculata.

WILL—Crataegus cyanophylla, C. laxiflora, Equisetum ferrissi, Ranunculus delphinifolius f. rosiflorus, Trillium recurvatum f. luteum.

WINNEBAGO—Amaranthus ambigens, Dodecatheon meadia f. alba, Lechea stricta, Persicaria spectabilis, Quercus bebbiana, Q. fernowi, Silene antirrhina var. divaricata.

SOUTHERN ILLINOIS, without definite locality, but south of 39° North Latitude

Agrostis aspera, A. lateriflora, A. racemosa, Andropogon avenaceus, Ambrosia bidentata, Ampelopsis cordata, Aristida oligantha, A. ramosissima, Aster pilosus, A. sericeus, A. villosus, Capraria multifida, Carex rectior, Chloris curtipendula, Chrysopsis camporum, Coreopsis aristosa, Croton capitatus, Dilepyrum minutiflorum, Eleusine mucronata, Festuca polystachys, Helianthus canescens, H. tomentosus, Juglans olivaeformis, Leersia lenticularis, Liatris aspera, L. cylindracea, L. pycnostachya, L. spheroidea, Mimosa illinoensis, Monniera rotundifolia, Oenothera glauca, Pedicularis lanceolata, Penstemon nuttallii, Phaseolus paniculatus, Plantago aristata, P. atrofusca, Poa pectinacea, P. sesleroides, Prenanthes aspera, P. crepidinea, Quercus prinus var. tomentosa, Rudbeckia pinnata, R. subtomentosa, Salix eriocephala, Salsola platiphylla, Scutellaria parvula, Silphium integrifolium, Verbena bracteosa, V. stricta, Vernonia fasciculata.

The Anatomy of the Flower of Boerhaavia repanda Willd.

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Introduction.—While engaged in a study of the life-history of *Boerhaavia repanda* (Bhargava, 1932), I prepared some material for a study of the vascular supply to the floral organs, but the work could not be published earlier due to several reasons. Since then Joshi and V. S. Rao (1934) published an account of the vascular anatomy of the flowers of four members of the family Nyctaginaceae including *Boerhaavia repanda*. This makes it unnecessary for me to describe my observations in detail and therefore, I shall limit myself to a few important points.

The material used for this study was collected partly from Bharatpur and partly from Lucknow and fixed in formalin-acetic alcohol. Sections were cut 8 microns thick and stained in crystal violet and erythrosin. This combination brought out the vascular bundles very clearly.

Acknowledgment.—I wish to express my sincere thanks to Prof. P. Maheshwari of Delhi University and to Prof. A. J. Eames of Cornell University for very kindly examining some of my slides and going through the manuscript. Their advice on several critical points has been of great value to me.

Observations.—The inflorescence is an umbel and the flowers are bracteolate with long slender pedicels. The perianth is pink, funnel-shaped and about half an inch long. The lower portion persists and forms a sheath over the fruit which is single seeded. Duthie (1915) gives the number of stamens as four or five, but I find that there are often only three (Figs. 7-14) or two (see also Joshi and V. S. Rao, 1934). The long filaments are united at the base to form a very short staminal tube as in *Mirabilis jalapa, Bougainvillea spectabilis, Boerhaavia diffusa* (Joshi and V. S. Rao, 1934), *Digera arvensis* (Joshi and C. V. Rao, 1934) and *Chenopodium album* (Bhargava, 1936). The carpel is situated on a short stalk or gynophore, and contains a single ovule (Fig. 15).

At the base of the pedicel there is an outer ring of about seven vascular bundles enclosing a variable number of medullary bundles (Fig. 1) as in the vegetative stem. The former have nothing to do with the vascular supply of the flower and disappear at the base of the receptacle. The medullary bundles arrange themselves to form a complete cylinder (Fig. 2) which soon expands and becomes broken up into ten vascular strands which are of two sizes; five larger alternating with five smaller ones (Fig. 3). The smaller strands pass out directly to the perianth and a little higher up each

1 The perianth consists of five segments in *Boerhaavia repanda*, but each segment itself consists of two distinct lobes in the lower half of the flower.

of the five larger ones sends out a further trace (Fig. 4) so that each perianth segment[1] receives two vascular strands *i.e.* ten strands are given out in all (Fig. 5). A little later each of these bundles divides to form three traces of which the two laterals are much smaller than the median (Figs. 6-10). At the base of the style the central bundle of each group divides further into a number of smaller traces (Fig. 11), but this is soon followed by a fusion of all the bundles so that once again there are only ten bundles (Fig. 12), two in each perianth segment. Gradually five of these bundles become reduced in size and they alternate with the five larger ones (Fig. 13). All of them now divide again and irregularly anastomose among themselves. Ultimately there are fifteen bundles in the perianth *i.e.* three for each segment (Fig. 14).[2]

A little above the level at which the perianth traces are given out, the remaining bundles unite to form a ring (Fig. 5) which breaks up into five strands (Fig. 6). Three of these pass out one after the other to the three stamens, each receiving a single trace (Figs. 7-14).[3] The remaining two traces, one small and one large, are the carpel traces (Figs. 7-8). The smaller bundle passes up unbranched along the dorsal side of the carpel (Figs. 9-14) and ends into the stigma; the larger bundle passes up along the ventral side opposite the dorsal trace (Figs. 9-10), and abruptly turns inwards to supply the ovule (Fig. 15).

The development of the carpel has already been described in my previous paper (Bhargava, 1932) and it is unnecessary to repeat those observations here. On the ventral side of the carpel, that is, in the region where it closes over, two strands of procambial cells make their appearance (Fig. 9). They unite (Fig. 10) and continue up the style as one strand, finally fading into the stigma like the dorsal trace. In older ovaries, this tissue becomes connected with the disorganized cells of the funiculus and the nucellar beak. Its only function seems to be the conduction of the pollen tube and it may, therefore, be called the transmitting tissue.[4] In an interesting paper entitled *Morphology of the Stylar Canal in Angiosperms*, Joshi (1934) expresses the view that since the stylar canal occupies the same position as the ventral traces it should be regarded as derived from them. This conclusion appears to him to be quite obvious. He says, "With the origin of the closed carpel with its distinct style and stigma from an open sporophyll, nothing could be more simple than that the pollen tubes, in order to reach the ovules in the lower part of the carpel, should pro-

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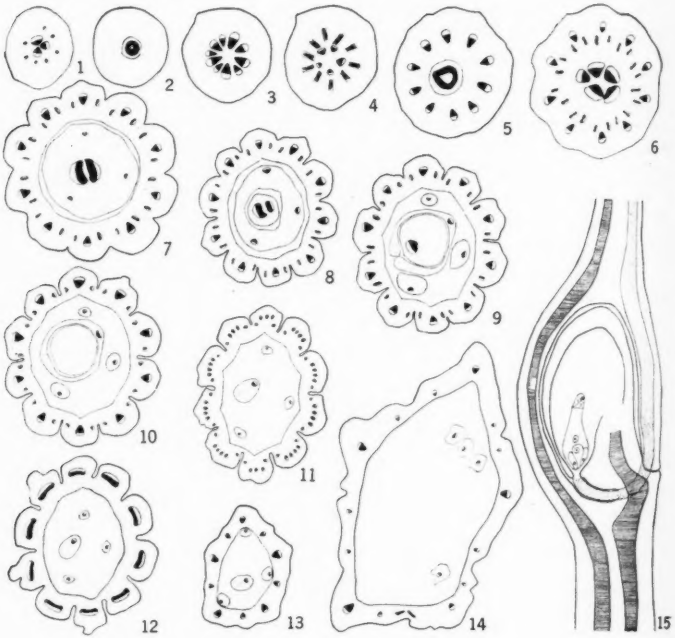
2 Joshi and V. S. Rao (1934) make no mention of the above details and merely state that the ten original strands run undivided through the greater length of the limb (perianth tube) except at the top where they break up into smaller bundles before fading away.

3 The flower described here had three stamens, but their number varies from two to five, and there is a corresponding variation in the number of staminal traces. After the departure of the perianth traces, the vascular tissue of the receptacle breaks up to form the same number of bundles as the stamens plus two additional bundles for the carpel.

4 The term 'conducting tissue' is not so appropriate because it implies the presence of vascular elements. See also Thomas (1934).

gress through some of its vascular bundles. The ventral traces would be the obvious channels since the ovules are borne on the ventral side, and the earliest stylar canals must have originated by a mere cessation of the differentiation of the ventral traces of the carpel at the procambial stage. The solid type of stylar canal is, therefore, to be regarded as primitive. That this is the form found even at present day in the majority of angiosperms supports such a conclusion. The hollow type of stylar canal with only a lining of conducting tissue is to be regarded as a derived and more recent condition."



Figs. 1-15. Cross sections of the flower at successive levels, ×27.—1. T. S. pedicel at its base. 2. Same, at the base of the thalamus. 3. Differentiation of the central axis into ten bundles. 4. Departure of perianth traces. 5. Perianth traces far out and the reformation of the central cylinder. 6. Each of perianth traces has divided into three; inner ring broken up into five bundles. 7. Departure of staminal traces; two bundles left in the center. 8. Staminal tube with three traces. 9. One of the carpellary traces has entered the dorsal wall of the ovary and the other has entered the ovule; on the ventral side are seen the two strands of procambial cells. 10. The two strands have united. 11-14. Successive sections leading towards the top of the flower. 15. L. S. lower part of a carpel showing the dorsal trace (d), the fused ventrals (v) and the transmitting tissue (t) ×63.

My observations, like those of Guéguen (1900-1902) and Arber (1937), indicate that the transmitting tissue of the style has nothing to do with the ventral bundles but arises in the usual way from the cells belonging to the epidermal and subepidermal layers of the carpel.

Joshi's whole theory is based on very meagre evidence (an examination of only ten genera belonging to the families Phytolaccaceae, Nyctaginaceae,[5] Thymelaeaceae and Aizoaceae). The assumption that the modern closed carpel must have originated from an open megasporophyll of the *Cycas* type would now be opposed by many botanists. The idea that the pollen tubes would find it easy enough to make their way through some of the vascular bundles is difficult to understand (unless a failure of vascular tissue to differentiate into its component elements started long before the evolution of the pollen tube). Besides, what about the host of angiosperms in which the ventral traces of the carpel are present and still the stylar canal is differentiated in addition to these? On the other hand, there are the recent discoveries of Harris (1933) and Johri (1936) which tend to indicate that the hollow style may well have been the more primitive and the solid style derived from it.[6]

Conclusions.—Interest in the rôle of floral anatomy with a view to determine relationships is of comparatively recent origin. The chief published accounts on the Centrospermales deal with the following plants: *Beta vulgaris* (Artschwager, 1927), two genera of the Caryophyllaceae (Saunders, 1925), a few members of the Phytolaccaceae (Saunders, 1934), five species of the Nyctaginaceae (Saunders, 1935), *Rivina* (Joshi & V. S. Rao, 1933), four members of the Nyctaginaceae (Joshi & V. S. Rao, 1934; Arber, 1937), ten members of the families Phytolaccaceae, Nyctaginaceae, Thymelaeaceae and Aizoaceae (Joshi, 1934), *Gisekia, Mollugo* and *Trianthema* (V. S. Rao, 1936), *Digera* (Joshi & C. V. Rao, 1934) and *Chenopodium* (Bhargava, 1936).

As pointed out by Joshi and V. S. Rao (1934), it seems evident that the floral anatomy of all the Nyctaginaceae so far investigated shows a great resemblance to members of the family Phytolaccaceae, like *Rivina* (Joshi and Rao, 1933; Saunders, 1930). In this genus the carpel receives three traces of which one is the dorsal trace and the other two unite to form the supply to the ovules. The only point of difference seems to be that in the Nyctaginaceae the two ventral traces are fused from the very beginning so that there are only two bundles at the base of the ovary instead of three. One of these is clearly the midrib or dorsal bundle of the carpel and the other is the ventral bundle which abruptly turns inwards and supplies the ovule. Reduction has resulted in the loss of the ventrals beyond

5 The observations made on this family have not been confirmed by other workers (see Arber, 1937).

6 Since these lines were written Joshi (1947) has withdrawn from his original position and his present views seem to be in agreement with mine.

this point, since they are of no functional value in such a reduced ovary.[7]

An important difference between my view and that of Joshi and V. S. Rao (1934) is that they regard the ovule of *Boerhaavia repanda* as basal while I now think that it is really lateral, although seemingly basal.

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[7] In *Pastinaca sativa* (Jackson, 1933) also, a member of the family Umbelliferae, the two ventrals are fused from their very origin. Eames (1931, p. 160) writes: "Reduction in size of the ovary brings the traces closer together at base and this approximation leads to fusion. When reduction in the ovary is greater this fusion becomes more extensive, reaching for considerable distances along the ventrals, or throughout their length, and even including the dorsal bundle from its origin to the base of the loculus."

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